THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL.

VOL. 31. Thursday, April 16, 1925. No. 452.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial, 17s. 6d. per annum.
All Subscriptions are payable in advance.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of

THE FOUNDRY TRADE JOURNAL,
BESSEMER HOUSE, 5, DUKE STREET, ADELPHI,
LONDON, W.C.2.

Contents.

	PAGE
The Growth and Tendencies of Foundry Technology	319
Correspondence	320
Two Refractory Material Experts Leave Britain	320
Castings for Diesel Engines	321
Iron and Steel Institute	325
The Formation of Graphite in Cast Iron	326
Institute of British Foundrymen	330
The Improvement of Cast Iron by Alloy Additions	331
Discussion on Mr. G. Edginton's Paper on "Oil-Sand Cores"	335
Trade Talk	338
Obituary	338
Iron and Steel Markets	338

Forthcoming Events.

APRIL 18.

Institute of British Foundrymen (Lancashire Branch, Junior Section):—Ordinary meeting at Manchester. "Foundry Materials," Paper by A. Hill.

Institute of British Foundrymen (Birmingham Branch):—Ordinary meeting at Birmingham. "Extending the Uses of Oil Sand Cores," Paper by F. C. Edwards.

APRIL 20.

Sheffield Society of Engineers and Metallurgists:—Ordinary meeting at Sheffield. "Cobalt for Magnet Purposes," Paper by E. A. Watson.

Institute of Transport:—Ordinary meeting in London. "Shipping from the Provinces," Paper by F. T. Walker.

APRIL 20-22.

Royal Microscopical Society of London:—Conference at Sheffield.

APRIL 23.

Institution of Welding Engineers:—Fifth winter meeting in London. "Overheating in Acetylene Generators," Paper by Charles Bingham, C.E.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

Institute of British Foundrymen.

PRESIDENT, 1924-25, R. O. Patterson, Blaydon-on-Tyne.

LIST OF SECRETARIES—

General Secretary: W. G. Hollinworth, 38, Victoria Street, London, S.W.1.
Lancashire: T. Makemson, 21, Beresford Road, Gorse Hill, Stretford, Manchester.
Birmingham: H. James Roe, 33, Herbert Road, Bearwood, Birmingham.
Sheffield: R. Village, Albion Foundry, Whittington Moor, near Chesterfield.
Scottish: J. Bell, 60, St. Enoch Square, Glasgow.
London: H. G. Sommerfield, Charterhouse Chambers, Charterhouse Square, London, E.C.1.
Newcastle-on-Tyne: Colin Gresty, 93, Queen's Road, Monkseaton, Northumberland.
East Midlands: H. Bunting, 17, Marcus Street, Derby.
West Riding of Yorkshire Branch: A. Love, 232, Gladstone Street, Bradford.
Wales and Monmouth Branch: J. J. McClelland, M.I.Mech.E., Druslyn, Bishops Road, Whitechurch, Glam.

Welsh Engineers' and Founders' Association.

Secretary: F. J. Griffiths, 20, Fisher Street, Swansea.

Foundry Trades Equipment & Supplies Association.

Secretary: K. S. Bridges, Avenue Chambers, Southampton Row, London, W.C.1.

The Growth and Tendencies of Foundry Technology.

A matter which is insufficiently recognised by the average foundryman is the numerous organisations which are working for his benefit. We have just been turning over the pages of the first volume of THE FOUNDRY TRADE JOURNAL (1902), at which time there was no foundry technical Association in Great Britain. At that time the American Foundrymen's Association was six years old, and certainly there was no French technical Association, or, we believe, a German one. Moulding machines had certainly made their appearance, but only to a very limited extent. High-speed steel was two years old, and the first electric-steel casting had still to be made. Steel castings at that time were very rough articles, as the sand question was inadequately understood. Scientific control in non-ferrous foundry work was practically non-existent.

To-day in the world there are something like 400 foundry technical Papers read every year. A system of exchange Papers was inaugurated about four years ago, and by the end of this year these, together with the unofficial ones, will number close on one hundred.

Of pure foundry research organisations, there exist, roughly, one for each of the great metallurgical countries, but these are supplemented by work carried out in national, public and private metallurgical laboratories. In Great Britain there is only the British Cast Iron Research Association which is exclusively devoted to foundry matters, but other organisations such as the National Physical Laboratory and the British Non-Ferrous Metals Research Association are also contributing their quota, the latter now making a special effort to interest non-ferrous foundry owners in their work. If there is sufficient response, a special department will be formed, an expert staff being available. The metallurgical departments of the Universities, too, carry out much research work for the foundries. Obviously, with such a mass of technical data so rapidly becoming available, it becomes increasingly difficult for the man in the foundry to keep abreast of the times. What actually happens is perhaps best visualised by reviewing some of the outstanding metallurgical developments which have influenced or will effect foundry endeavour. Primarily, there was Professor Turner's work on the influence of silicon on cast iron; then came Mr. Cook's phosphide eutectic network structure: afterwards, there was semi-steel; and finally, pearlitic cast iron. In each case these factors have temporarily dominated ironfoundry thought and perhaps too closely narrowed the main issue, usually against the best judgment of the originator. There is a constant need of effort in metallurgical foundry practice to deflect thought in orthodox channels and to put each order of research work into its proper perspective.

So, too, it would seem advisable that the closest co-operation should be instituted between the various research organisations themselves and the actual in order that (1) research of the valuable type is undertaken; (2) the avoidance of unnecessary overlapping; (3) the elimination of wasted effort, such as duplication in the matter of translations and extracts; and (4) the periodic marshalling of known facts and data so as to focus attention to matters in the order of the relative importance, with the object of preventing the latest discovery from temporarily submerging prior established or orthodox thought. It is well known that a new specific rapidly loses its curative power.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Marine Castings and the Price of Ships.

To the Editor of The Foundry Trade Journal.

Sir,—In a leading article entitled "A Commercially Voiceless Industry" in your issue of March 12 you state that "even the daily Press has hinted that it is largely the price of castings which has influenced" the placing of British shipbuilding orders in Holland and Germany.

I should have thought that a journal representing the foundry trade would have devoted its energies to refuting such a suggestion rather than to quoting it without comment. I am afraid that an outsider reading the article may conclude that, in your view, there may be substantial grounds for the suggestion. This is very far from being the case, as may quickly be seen from an examination of the facts.

If we assume that a British tender for a steamer of 7,000 or 8,000 tons is approximately £120,000, the total weight of iron castings involved would be roughly 150 tons. Even if the foundry prices were cut by 20 per cent., this would effect a reduction of only some £600 on a total cost of £120,000. As everyone well knows, the difference between British and foreign prices tendered for the ships in question ran to many thousands of pounds.

In point of fact, the present prices for marine castings at the foundries in this district are only about 50 per cent. above the 1914 level. Against this, moulders' wages have risen about 70 per cent., dressers' wages have risen by over 80 per cent., and labourers' wages by approximately 120 per cent. It is true that the increase in pig-iron prices is only somewhere between 45 per cent. and 50 per cent., but in coke I calculate the increase at over 70 per cent., in coal at over 85 per cent., and in gas works char over 100 per cent.: not to mention the increase in local taxation due both to increase in rates per £ and the very substantial raising of the annual value put upon industrial works.

On these figures it is impossible for anyone to say that the present prices for marine castings are unfair. The makers of marine castings know by sad experience that they can seldom recover at present rates any contribution towards their standing charges; and a profit seems to be a thing of the past.—Yours, etc.,

John H. Wilson.

Paisley,
April 10, 1925.

[Any effort of ours—or, indeed, any purely individual effort—to refute such a statement as Mr. Wilson quotes tends to defeat the main object we had in mind when writing the leader, "A Commercially Voiceless Industry." We still consider it essential for the general good of the industry that a national federation should be formed which, through its director, would speak with the whole weight of the trade behind it.—Editor.]

Semi-Steel.

To the Editor of The Foundry Trade Journal.

Sir,—Mr. H. Field's Paper, which appeared under above title in your last week's issue, contained much of great interest and value, and in thus congratulating Mr. Field I would like to add also a few comments.

This Paper, by means of some admirably thought-out and simple experiments, nails down much of the rubbish that has been published about the manner in which steel absorbs carbon in the cupola. It has ever been a mystery to me how our American friends have been wrong, so consistently, in their science of this subject, when anyone could prove otherwise by the simple expedient of suspending a bar of mild steel from the top to the tuyeres of a model cupola. That the greater part of the carbon is taken up only after the steel is no longer a solid is proved conclusively by such observations.

All this goes to show the need for scientific and trained men. I noticed in Germany that there the scientific man is equally a "practical" man, whereas here we attempt to divide the two occupations, with the result that neither understands nor assists the other. In America the position would appear to be far worse than in Britain.

Mr. Field appears to be in error when he says: "It is advisable to keep a fair percentage of manganese, *say* 0.6 *per cent., in the finished semi-steel*, but since most mild steel contains this amount, the steel addition will not rob the pig-iron, and *an initial content of* 0.6 *per cent. manganese in the latter* will be quite suitable." In the first place, mild steel rarely contains more than 0.5 per cent. manganese, and in the second place there is a loss of 10 to 20 per cent. of the manganese added to the cupola. Therefore, by following out Mr. Field's procedure, the finished iron would contain no more than about 0.4 per cent. at the most. Perhaps he makes it up by a ladle addition?

I disagree with Mr. Field's interpretation of his results and the manner in which he tries to attribute everything to the varying amounts of steel added. For instance, Table III has several varying factors other than the steel addition, the most notable being that the weakest iron contains 2.65 per cent. silicon and 1.38 per cent. phosphorus, whilst the strongest contains 2.0 per cent. silicon and 0.91 per cent. phosphorus. Therefore the two irons are not comparable and the physical tests are not due to the steel addition and could have been reproduced in other ways. This peculiarity of having several varying factors and ascribing the results to one of them only is common, unfortunately, to an enormous amount of the investigations published upon cast iron. If Mr. Field would continue his good work along the same lines, but allowing but one variation to occur in any one series, I feel sure that the value of his records would be enhanced.

He makes a most interesting and pregnant remark in saying: "Ironfounding has not yet reached the stage at which its products may be either accepted or rejected by a microscope test, *although the advent of Lanz pearlitic iron may be one more step* towards such an end." His perspicuity is admirable, and I can assure him that the Lanz process is the greatest step in grey iron foundry work which the world has seen; only those who have had the opportunity of investigating it will know, as yet, the immense stride and the amazing results embodied in this new discovery. It places ordinary foundry practice as a thing of the past, and ordinary grey cast iron as out of date and superseded by something better, and, what is more, definitely homogeneous and reliable in service.

There are many points in Mr. Field's Paper about which I would like to ask questions; possibly he will give us pleasure by coming to Newcastle next session? Such Papers as his are needed.—Yours, etc.,

Horace J. Young, F.I.C.

16, Ashfield Grove, Whitley Bay,
Northumberland.
April 11, 1925.

Two Refractory Material Experts Leave Britain.

On April 7 over 100 people, representatives of the members of the Sheffield Ganister Association, the Sheffield Compo Association, and the Refractories Association, participated in a most enjoyable dinner-dance at the King's Head Hotel, Sheffield.

The function was organised by the above Associations as an official send-off to Mr. J. Kent Smith, O.B.E., who is leaving Sheffield for the United States of America, and Mr. Percival W. Duckenfield, of Messrs. J. & J. Dyson, Limited, Sheffield, who is shortly leaving the country for Rhodesia. The gathering was presided over by Mr. Job Holland, President of the Sheffield Ganister Association, and the Sheffield Compo Association, and Mr. F. J. Boam, President of the Refractories Association.

During the evening framed illuminated addresses were presented to both Mr. Kent Smith and Mr. Duckenfield.

Mr. Frank Russell, who was responsible for the organisation of the occasion, was warmly thanked by all for the excellent entertainment.

Castings for Diesel Engines.

Conference between Scottish Foundrymen and Engineers.

The problems connected with the production of castings for Diesel engines formed the subject of a further conference in Glasgow recently between the Scottish Section of the Institute of British Foundrymen and the Scottish Section of the Institution of Mechanical Engineers. This is the second meeting held in the course of the present session between the local Branches of the Institutions, and it is believed that considerable benefit will result from the frank interchange of views between those engaged in the two allied industries. At the first meeting, which was fully reported in The Foundry Trade Journal of December 4, 1924, four Papers were read. Professor Mellanby dealt with "Temperature Stresses and Working Conditions of Oil Engines," Professor Campion with "Characteristics of Cast Iron for Oil Engines," Mr. James Richardson with "Oil-Engine Design as affected by Foundry Practice," and Mr. William Bell with "Oil-Engine Design from a Moulder's Point of View."

At the second joint meeting, at which Mr. Laurie presided, and which was largely attended by members of both Institutions, these Papers formed the basis of discussion. It is probable that

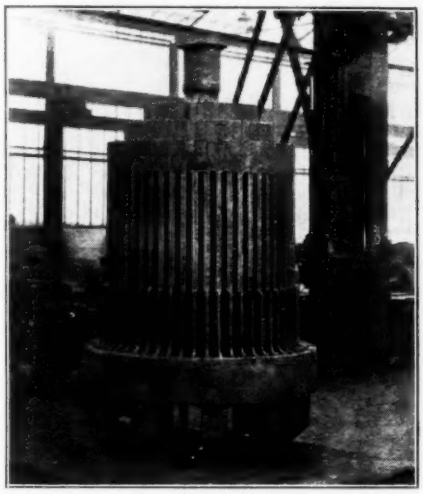


Fig. 7.

at a future date another conference may be held for the further consideration of the subject.

Inefficiency of Short-period Heating Tests.

Mr. Donaldson said: The four Papers on "Cast Iron for Diesel Engines" were of considerable interest, and brought out many points connected with this important subject. They emphasised the fact that difficult conditions have to be met—conditions so difficult and strenuous that one sometimes questioned, like Mr. W. Bell, if cast iron could really stand up to them. Professor Mellanby, dealing with the tensile strength of cast iron as the temperature rises, gave an interesting curve showing the strength of cast iron at elevated temperatures and under prolonged stresses. He discredited test results obtained where the test bars had only been subjected to a particular temperature for a short period before breaking. He agreed with him on this point, and had shown it by submitting test bars to a prolonged annealing at 450 deg. C. and 550 deg. C. before breaking at high temperatures, when results somewhat similar to those given in the Paper were obtained.

Chromium and Growth.

The growth tests shown in Fig. 3 in the Paper were of interest, as they showed not only that this property differs with various cast irons, but also that iron could be obtained which is particularly "non-growing." In connection with growth, he (Mr. Donaldson) had carried out a series of experiments, and found that with 0.4 per cent. of chromium an iron was obtained which did not grow, but, on the other hand, showed a small contraction on prolonged heating at 550 deg. C. (1,022 deg. F.). In connection with wear, Professor Mellanby makes the statement that resistance to wear may be associated with resistance to growth. This is a statement which is of great importance in dealing with Diesel engine castings, as Mr. Hurst pointed out in the subsequent discussion. In support of this statement, Professor Mellanby added that the iron of Curve 1, Fig. 3, came out equally well when its wearing properties were tested, and in this connection he would like to know if the other irons shown in Fig. 3 were also tested for wear, and if a similar relationship was obtained.

Low Phosphorus Content Favoured.

With regard to Mr. Campion's Paper, whilst agreeing in general with what he had said regarding the composition of the material, he was inclined to favour a rather low phosphorus content. Even with 0.5 per cent. there was always the tendency for segregation to take place, and this tendency could be reduced considerably by reducing the phosphorus to 0.2 per cent. without

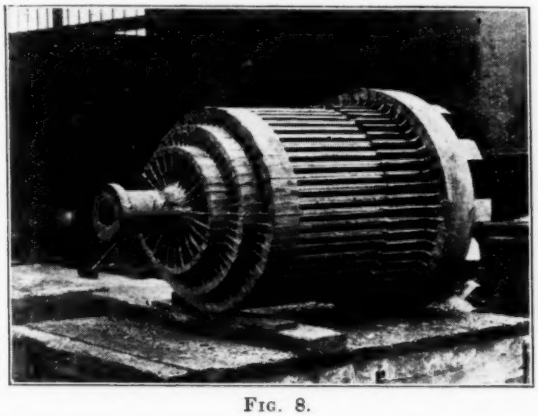


Fig. 8.

being detrimental to the casting. Mr. Campion also favoured a high manganese-content, but to prepare sound castings containing over 1.5 per cent. of manganese it was rather difficult, especially if the manganese was added in the form of ferro-manganese to the ladle. A small percentage of chromium, 0.4 to 0.5 per cent., produces slightly better effects so far as growth and stability of the carbides at high temperatures are concerned than 2.5 per cent. of manganese. Of course, there is the extra cost and the question of introducing the chromium, but the latter difficulty should be overcome to a great extent by using the chromium pig-irons which are now available. Mr. Campion also favoured the use of the reverberatory furnace for melting, and this was certainly desirable, and also the introduction of a certain percentage of steel scrap in order to obtain the desired structure, high strength, and other properties necessary. Pyrometric control in casting could also be more generally adopted with advantage.

Continental Conditions Discussed.

Mr. Richardson in his Paper gave Continental foundry practice a large amount of credit which did not appear to be altogether justified. His drawing of an integral casting appears to be satisfactory, but designers would be better to ask for such a type only in small sizes where there were large margins in strength. The engineer who proposed such a casting for an engine of the size shown by Mr. Richardson in Fig. 4 in his Paper was asking for more than he is entitled to demand, and if such castings were produced on the Continent, successful results with them must be very

much of a lottery. No one could say how the stress was distributed in such a casting, and, even with scientific cooling provided, it was doubtful if the results obtained would justify the faith Mr. Richardson put in this type of casting. In the Paper by Mr. Bell, the many difficulties experienced by the moulder in dealing with these intricate types of castings were fairly considered, and indicated one point where the present series of Papers should help considerably, namely, the pressing need for collaboration between all those interested in this highly important subject.

Heat Stresses.

Mr. Vincent said he was particularly interested in the references that had been made to heat stresses. His attention was drawn to this matter some three or four years ago, but he found that in the majority of text-books a formula was given something on the following lines:—

Heat stresses = $\frac{d\ (T_1 - T_2)\ E}{2}$. This is obviously in error, as it takes account of stresses only in one direction. At one time he had cause to examine the problem, and, as another step forward, incorporated two stresses at right angles, when he had stresses = $(1 + m)\ \frac{1\ (T_1 - T_2)}{2}\ E$, *i.e.*, an increased stress. Not being satisfied with this, Mr. Vincent said, he turned to the theory of flat plates and deduced a formula, but here the result obtained was so complicated that for practical

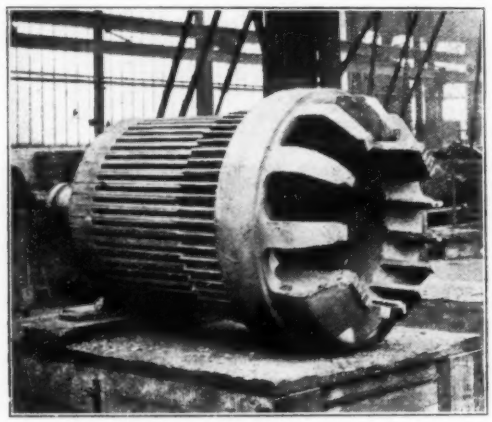


Fig. 9.

purposes it was useless. He observed in the "Journal of the Institute of Mechanical Engineers" recently a treatment of this subject so far as the liner is concerned, but here again for ordinary purposes the results are too elaborate. It must be borne in mind that the average person during calculations fought shy of mathematics. He suggested to Professor Mellanby that he might apply himself to the problem and deduce something fairly easy to use and yet giving greater accuracy than the above. The results mentioned in the "Journal" were from an old engine having a high fuel-consumption and probably out of date from modern standpoints. It was certainly very unfortunate that our professors only had the chance of working on old gear that has been discarded for commercial use; the results obtained are of use, but cannot be applied to modern conditions in most cases without assumption. The differences between engines of 10-30 h.p. per cylinder and modern ones of 400-500 were very great, and a great step forward would be made if the academical men could work upon up-to-date machines.

Suggested Elimination of Cast-Iron.

Turning again to the question in hand, it was obvious that the thickness must enter into the problem; the thinner the metal the less the stress due to heat-flow. There were various examples where attempts have been made to do this, *e.g.*, the Doxford and Still engines, particularly the latter, but here the factor was carried to the extreme, resulting in a very difficult casting, at the same time involving shrinking on bands of steel, etc., and the result was still a very heavy article. He therefore suggested the abandoning of cast iron—one of the weakest metals—and the use of a stronger one, namely, steel, when the thicknesses could be reduced by half without elaborate ribbing, resulting in a corresponding reduction in the temperature stresses. Of course, the full advantage of steel cannot be obtained, since it is necessary to have rigid liner, additional metal has to be left on to secure freedom from distribution, but even so, great advantage results.

The marine world is very conservative, but it should not hesitate to adopt proved practice. Why not survey the automobile and aero-engine fields and gather in the experience gained? It is true that there the engines are relatively small, but none the less they are highly stressed and have running speeds far in excess of anything in the marine field. By this means great saving would result. Did it not seem absurd that one engine develops 1 h.p. for about 2¼ lbs. weight, whilst another requires 400 lbs., the maximum and mean pressures being similar? Assume 2¼ lbs. at 2,000 r.p.m., therefore at 200 r.p.m. weight per h.p. = 25 lbs. Reducing the rating by 25 per cent., therefore weight per h.p. = 32 lbs. approximately. Now allowing stresses 3/4 of aircraft practice, this coupled with the reduced frequency considerably reduced, the effective stresses and the weight

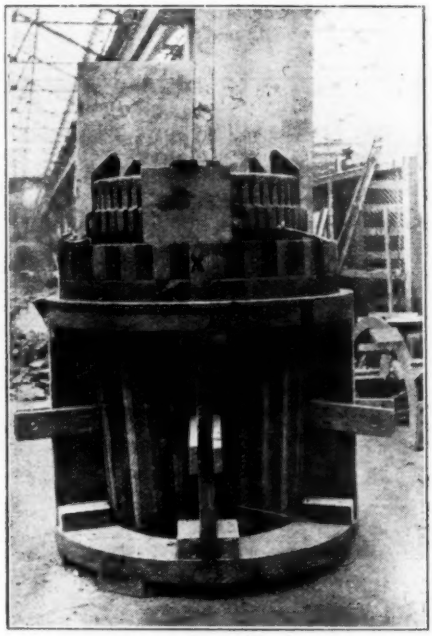


Fig. 10.

became 45 lbs. per h.p. For accessibility which spread the cylinders, etc., this figure could be doubled to 90 lbs. per h.p., and an engine should be obtained perfectly free from breakdown, and at the same time a great advance on present practice for slow-speed work. This was little in excess of the weight of such engines as those used at present for submarines, etc.

A car-engine in the average person's hands runs two or three years with no attention at all, so an engine as above, which was always being run by trained engineers, surely should be a sound proposition. Now, how is this to be carried out? Obviously by discarding cast iron. It is this material that is responsible for most of the weight of the present engines. Nearly all aero-engines of large size are fitted with steel liners, and they have proved very successful, giving a good life with piston speeds of 2,000 r.p.m. and over. Surely, then, a steel liner was possible at 500 to 900 r.p.m. Steel liners of 8 in. to 14½ in. have already been tried in some cases, and have proved successful, the weight reduction being considerable, while the engine was capable of continued operation at higher mean pressures than are possible with cast iron due to the reduced heat flow. In conclusion, he would like to suggest that some radical departure of the nature suggested should

be considered. If the industry was to expand beyond its present limits, 300 to 400 lbs. per h.p. must be altered, and the best way of doing it was to eliminate cast iron. Many doors, covers, etc., at present in this material could be made as easily in aluminium.

THE MAKING OF A "STILL" ENGINE.

Mr. N. McManus said: At the former meeting of the Institutes of British Foundrymen and Mechanical Engineers on diesel engine castings, reference was made during the discussion to the fact that engineers had to go to the Continent for these intricate castings, having regard to the workmanship and quality demanded. The Branch President of the Institute of British Foundrymen, Mr. Affleck, in reply to this remark, purposed showing what can be done in a British foundry with such castings when the problem was presented and sympathetic consideration given by the engineers. Unfortunately, he was away from home on business, and he had therefore been asked to reply on his behalf. Mr. Affleck's contribution reads:—

The casting he proposed describing was a combustion cylinder for the "Still" oil engine, with which, no doubt, many were already familiar.

Fig. 7 gives a general idea of the type of casting, which has a bore of 22-in. dia., terminating in a cone-shaped end, at the apex of which is a

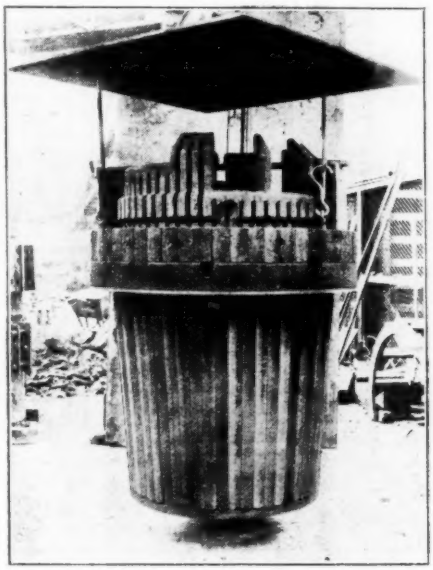


Fig. 11.

2¾-in. dia. hole entering the projection seen at the top of the casting; the thickness of metal in the cylinder wall is 0.62 in. Surrounding the cylinder there are a series of ribs, 55 in number, which extend the full length of the casting and surrounded with three belts, as seen on the upper portion. Fig. 8 shows these belts much clearer. The height of casting is about 5 ft. and weighs 25 cwts. Having now received some idea of the nature of the casting, it may be interesting to know that the whole scheme for making this casting was drawn up in the "Foundry Planning Department," and drawings prepared, giving complete details to the patternmaker for the patterns and core-boxes, also to the foundry for the procedure to be adopted in preparing the mould and cores, etc. Another departure from general practice that was adopted was to make both the mould and all the cores in oil-bonded silica sand.

Fig. 8 shows the cylinder lying horizontal and gives a more complete view of the ribs and belts, the ribs on the end being only ⅜ in. thick. This view also conveys some idea of the work involved in producing such a casting.

Fig. 9 is a view taken from the opposite end, and shows the projections which form the various ports in this cylinder; the narrow ones are solid, the others being cored out by the projecting portions of the rib cores, which is shown in Fig. 11. A feature of this casting is the method adopted for forming the ribs; each core is a separate one, and, as previously mentioned, there are 55 in number with 20 different types. These are all made from 4 half-core-boxes, which are fitted with loose removal pieces, so arranged that with the aid of a chart, the complete set can be produced, otherwise a number of core-boxes would have been required. Each core is made complete, and owing to its shape, which is very irregular, is dried on a sand bed, the bed being formed on the core before the box is drawn. The core cannot be made in halves, as the thickness of sand at one end is only ¼-in. thick.

Fig. 10 shows a set of these cores assembled and fitted together in a fixture, previous to placing in the mould. The assembly of these cores must be accurate and close fitting, and, reverting to Fig. 8, it will be seen that they have to follow the contour of the cylinder from the 2 ft. 11 in. dia. of the large belt at the right, down to the neck of the projection seen on the left, which is 4¼-in. dia. Each core has a back or print which is wedge-shaped and serves to strengthen the core and facilitate the building. Fig. 15 makes this point more clear. In assembling this core, there are what are called so many "master cores" inserted first, which have a special locating lug formed on them. One is seen on Fig. 10 at X. The intervening spaces between these are then filled in.

Fig. 11 illustrates the assembled core lifted out of the fixture and ready for lowering into the mould. It will be noticed that the diameter of the core is tapered to suit the mould, which is also tapered. This was done to facilitate closing and also to reduce the weight of the rib cores. The core seen at the base is for the purpose of locating

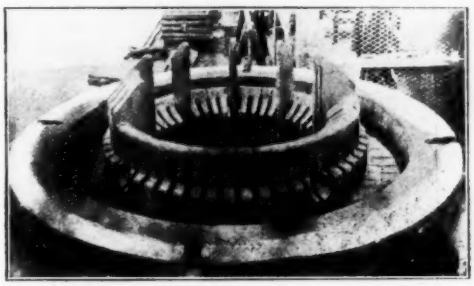


Fig. 12.

the cores to give the correct position relative to the cylinder barrel contour, each rib having a recess which fits over a ring formed on this core. In a similar manner the large ring core also locates the upper portion for diameter as well as spacing. The weight of this core is carried by a steel ring seen below the large ring core, and to which hook bolts are attached; the base plate core is also kept in position while lifting by a suitable hook bolt attached to the lifting plate, this being removed after the core is set into the mould. The steel ring remains in the mould.

Fig. 12 is a view looking on the top of the mould with the assembled rib cores in position, and ready for the barrel core to be placed in position, and Fig. 13 shows the mould built up of three rings made with oil-bonded sand; no boxes are used, but a sheet steel band is placed over the joints, being a case of "Safety First," so as to prevent any possible accident due to bursting. These rings are about 5 ft. dia., 19 in. deep, and have a tapered bore, which is approximately 3 ft. dia.

Mr. Ross, of the Argus Foundry Planning Department, has prepared diagrams (Figs. 14 and 15), one showing the complete arrangement of the mould in which is shown the barrel core in position and the closing top core, neither of these having been shown in previous views; and one giving a section through the assembly of cores (Fig. 15). It is hoped that these brief remarks have at least been interesting and that they have conveyed some idea of what can be done when some consideration is given to the foundry by the engineer, but it must be clearly understood work of this nature requires much more attention, the risks are

greater, and the metal "special." Therefore, when buyers are considering quotations, they should not be biased by the lowest price quoted. The speaker then asked Mr. Ross to explain Figs. 14 and 15.

Foundry Planning for a "Still" Engine.

Mr. E. Ross said Fig. 15 is a sectional view showing the arrangement of the mould for the casting of a Diesel engine cylinder. The entire moulding and casting process is carried out to a planned scheme of operations to ensure definite control and accuracy at every stage of the process. In foundry planning it is necessary to keep in view the duty of the casting and the quality necessary, both as regards material and requirements of design.

Every core of itself has a specific purpose and is arranged and made accordingly. There are in all 63 cores, as follows:—Three external cores, forming the mould; one core behind the flange at the bottom; one master core at the bottom (a complete circular disc), which positions the rib cores by a registering key; one master core at the top (complete ring), positioning the rib cores by a registering key; 55 rib cores (29 different designs) made in four adjustable boxes; one

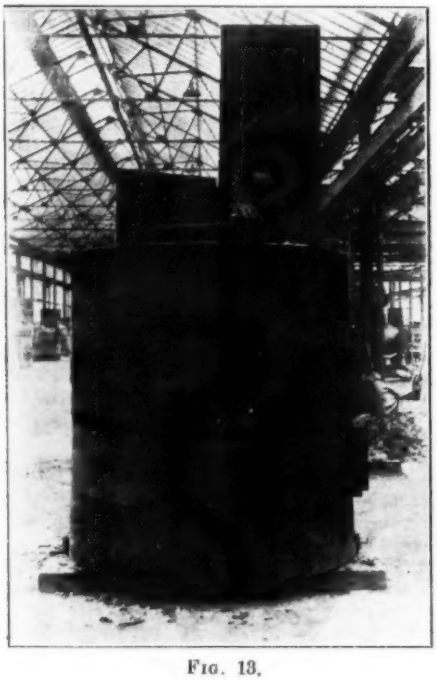


Fig. 13.

barrel core; and one top or closing core, making all the scavenge and exhaust ports, runners and risers.

When the exceptionally thin sections for such a large core of a cylindor and the general intricacy of the casting are considered, the advantages of having every step planned for the manufacture and building of mould and cores are very obvious.

The finished thickness of barrel of $\frac{5}{16}$ in. does not give any allowance for discrepancies in alignment, therefore it is absolutely necessary to have all cores accurately registered and rigidly held in position. The barrel core is registered by a bottom print and is centralised at the top and held in position by the closing core. The rib cores are positioned by the registering keys on master cores. The building of the barrel, comprising the 55 rib cores, is of itself quite a formidable job, but may be carried out quite easily by means of the appliances provided.

If engineers were asked to produce a similar article in steel or iron they would demand the finest and most expensive machines and tools. To make a success of this casting the foundryman is called on to produce a barrel built with staves of sand. Probably designers and draughtsmen do not quite realise that there are limits to what can be made in sand, having in view the commercial side of the question. As progress is made in engineering, designs in many cases become an accumulation of additions or alterations to the original design. These additions are very often embodied in the design without consideration for the difficulties which they may occasion in the foundry.

The Chairman remarked that some people said that if they wanted a good article let them go to Germany for it, but he thought that the work which had just been described and illustrated would be difficult to improve upon. It was a job made up purely of cores. If that became a standard casting it would no doubt become much cheaper, but where one had to do all the experimenting and make money at the same time it was very difficult.

Question of Costs and Quality.

Mr. James Richardson, B.Sc., said every shipbuilder and engineer in this country was trying to induce the shipowner to order new tonnage, but the shipowner was naturally only willing to do so at an economical price, and unfortunately the shipbuilder and marine engineer were unable, in this respect, to meet his wishes. We sought to reduce the cost of shipping tonnage to such an economical level that the shipowner will buy.

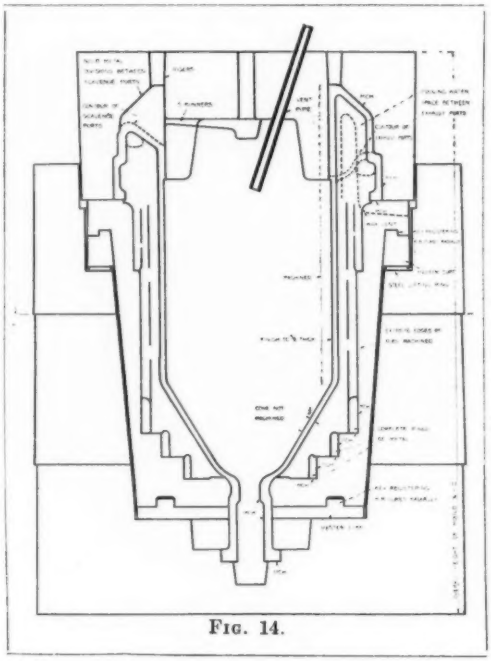


Fig. 14.

There was no difficulty whatsoever in regard to reducing, by a very considerable amount, the weight with the standard design of marine machinery, whether steam or Diesel. If steel were used instead of cast iron for certain parts, and aluminium substituted for others, then the weight would be very much reduced, but the cost would be greater, leaving us in a still worse position to meet competition. The difference in scantlings used by various makers of engines mentioned by the chairman is understandable. Many owners have their own ideas in this matter. For example, take the case of commercial motor vehicles, where different buyers will choose different types. Some require slow running engines, while others will readily take the risk of high maintenance charges in order to obtain a figure of low first-cost. In exactly the same way some shipowners are not willing to pay an extra price for a design with a high factor of safety and probably low maintenance charges.

He felt that the engineer would ask the foundryman to satisfy his requirements in regard to castings, without any inordinate increase in the cost per cwt. or per ton in these castings. It is inevitable that the question of cost should come into this discussion. Secondly, the engineer must be satisfied as to the definite physical qualities of the castings, in order to avoid the risk that it might prove unreliable. The illustrations of

design which he gave in the Paper he read at the former meeting must not be taken to represent actual practice. They simply represent basis designs in order to indicate the nature of the simple problems with which designers were commercially faced to-day. The present position was that there is no difficulty in building a set of machinery to fulfil the shipowner's specification, and there should be no difference in the foundryman's case of the way in which the design was tackled in the design stage. Nevertheless, we sought to get down to a commercial basis, and in order to secure work, the engineer had to undertake onerous guarantees for the machinery for which he tendered. He must definitely specify, in many particulars, the performance of the engine in question. Therefore he asked the foundryman to assist him by guaranteeing the physical quality of the castings supplied, thereby to lessen the risk which the engineer had to undertake in regard to the whole contract.

The question of Brinell hardness or other suitable tests, should be studied, and figures should be capable of being specified by the foundryman as well as other physical properties which can readily be measured by the buyer. If the foundryman and the engineer could get closer together amicably to discuss these questions, he was sure the result would be the removal, if not of all, at least of some of the difficulties.

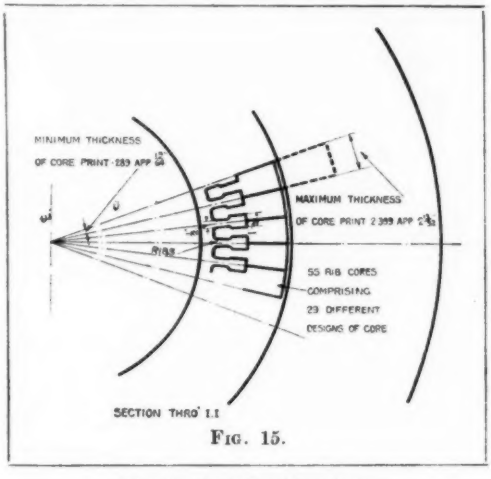


Fig. 15.

Metallurgical Considerations.

Mr. J. Arnott said he proposed to limit his remarks to the metallurgical side of the subject, with which Mr. Campion has dealt in a general way. When one examined the figures he (Mr. Campion) suggested for the various elements, he found nothing differing in any way from what is at present being used for steam cylinder and similar castings. His figures were:—Total carbon (maximum), 3.25; Si, 1.0 to 1.5; P, about 0.5; S, 0.05 to 0.08 per cent., and for Mn no figures were given.

There was nothing distinctive about that. Several firms were making quite ordinary castings (steam cylinders) every day of metal which exactly met these limits. In considering the subject of the metal for the highly-stressed and heated parts of Diesel engines, there appeared to the speaker to be two definite questions to be answered. First, did we know what composition is best suited for the work? Second, could we make castings of such a composition at a reasonable price? With regard to the first question he ventured to say that we did know what was wanted, and were in a position to draw up a definite specification.

(To be continued.)

Vickers and International Combustion Engineering, Limited.—Mr. G. E. Leanard, of the American concern, has just arrived in this country, accompanied by Mr. W. R. Wood, of the Underfeed Stoker Company. Mr. Leanard will probably spend a couple of months in Europe, in the interests of the Vickers and International Combustion Engineering, Limited, the Underfeed Stoker Company, and other concerns associated with the American Corporation, and with a view to extending the use of the Corporation's process for the utilisation of pulverised fuel.

Iron and Steel Institute.

ANNUAL MEETING, 1925.

As previously announced, the annual meeting of the Institute will be held at the Institution of Civil Engineers, Great George Street, Westminster, on Thursday and Friday, May 7 and 8, 1925, commencing each day at 10 a.m. The annual dinner will be held at the Hotel Cecil, Strand, W.C., on the evening of Thursday, May 7, at 7 for 7.30 p.m. Tickets are 15s. each, exclusive of wine.

The following Papers are to be presented:—

(1) "The Effect of Grain upon the Fatigue Strength of Steels," by L. Aitchison and L. W. Johnson.

(2) "A Method for reducing the Percentage of Phosphorus in Swedish Iron by diminishing the Phosphorus in the Charcoal," by H. von Eckermann.

(3) "On the Structure of Quenched Carbon Steels," by B. D. Enlund.

(4) "Estimation of Phosphorus in the presence of Vanadium," by G. Watson Gray and C. D. Garbutt.

(5) "Temper-brittleness of Steel: susceptibility to temper-brittleness in relation to Chemical Composition," by R. H. Greaves and J. A. Jones.

(6) "Note on Nitrogen as a possible Factor in Temper-brittleness," by W. T. Griffiths.

(7) "Progress in British Rolling-mill practice," by T. W. Hand.

(8) "'Flakes' or 'Hair Cracks' in Chromium Steel, with a discussion on 'Shattered Zones' and 'Transverse Fissures' in Rails," by A. Hultgren.

(9) "'Peeling' in White Heart Malleable," by D. H. Ingall and H. Field.

(10) "The Influence of Gases at high Temperatures upon Iron, with special reference to the formation of Blowholes," by A. G. Lobley and C. L. Betts.

(11) "Some Notes on the use of a Diamond Pyramid for Hardness Testing," by R. L. Smith and G. E. Sandland.

(12) "The Detection of Strain in Mild Steels," by T. Henry Turner and J. D. Jevons.

(13) "Strain Detection in Mild Steel by Special Etching," by J. D. Jevons, and

(14) "Observations on Martensite and Troostite," by J. H. Whiteley.

AUTUMN MEETING, 1925.

The autumn meeting will be held in Birmingham on Wednesday, Thursday and Friday, September 9, 10 and 11. A provisional programme of arrangements has been drawn up by the local Reception Committee, of which Mr. George Hatton, C.B.E., member of Council, is chairman, and Professor T. Turner, M.Sc., member of Council, vice-chairman. These arrangements comprise the usual business sessions of the Institute for the reading and discussion of papers, a reception by the Lord Mayor of Birmingham, a reception at the University of Birmingham, a luncheon, at which the visiting members will be entertained by the Reception Committee, visits to numerous works in Birmingham and the adjoining district, and an all-day excursion on Friday, September 11, to Kenilworth, Warwick Castle and Stratford-on-Avon.

The Physical Chemistry of Steel-Making Processes.

A joint general discussion will be held by the Iron and Steel Institute and the Faraday Society on Monday, June 8, 1925, from 3.30 p.m. to 7.30 p.m., at the Institution of Civil Engineers, Great George Street, London, S.W.1. The following provisional programme has been arranged:—

(1) Introductory address, by Sir Robert Hadfield, Bart., F.R.S.

(2) "The Theory of Equilibria in Steel Furnaces," by Professor C. H. Desch, F.R.S.

(3) "Balance Reactions in Steel Manufacture," by A. McCance.

(4) "Slag Reactions," by P. MacNair.

(5) "The Reactions of the Basic Furnace," by Mr. T. P. Colclough.

(6) "The Function of Ferric Oxide in the Acid and Basic Open Hearth Processes," by Mr. J. H. Whiteley.

(7) "Chemical Reactions in the Basic Electric Process in the United States," by Mr. F. T. Sisco, and

(8) "Physical and Chemical Phenomena from Melt to Ingot," by Mr. A. L. Feild.

The Formation of Graphite in Cast Iron.*

By J. E. Hurst.

The most important constitutional feature in all forms of cast-iron alloys is the formation of graphite. This fundamental feature is often spoken of as the "graphitisation phenomenon." When we consider that all experience, investigation and discussion of all the factors controlling the physical and mechanical properties of castings lead us to the one conclusion that these properties are ultimately controlled by this graphitisation phenomenon, we at once realise the importance of this subject.

The exact nature of the mechanism of the formation of graphite in cast iron has long been a matter of considerable complexity, and even to-day has not been completely elucidated. The many and various views as to the nature of this phenomenon which have been expressed from time to time by investigators are often conflicting to such an extent that it is difficult for the foundryman to form any reasonable working hypothesis to guide him in his routine work.

The only way of clearing up the present conflicting and confusing position is by further research and direct experiment, and those who have considered this phenomenon at all deeply will realise the stupendous difficulties which are involved in further direct experiment.

It is the author's intention in this note to endeavour to review the whole subject of graphitisation in cast iron, and if possible to present the situation in such a way as to enable the reader to obtain a satisfactory working hypothesis of the nature of this phenomenon in so far as the facts as we know them will permit.

In considering the graphitisation phenomenon in cast iron it is convenient to divide the subject under four headings, which are the principal features in the phenomenon with which we are concerned as follows:—(*a*) The actual formation of the graphite; (*b*) the quantity of the graphite; (*c*) the size of the graphite, and (*d*) the distribution of the graphite.

These features strictly relate to the graphitisation phenomenon, and are admittedly the features controlling the physical and mechanical properties of cast iron.

The Formation of the Graphite.

It is necessary in view of the complications introduced by the various elements present in commercial cast iron to consider in the first place the formation of graphite in the pure iron-carbon alloys, neglecting the influence of any of the additional elements above referred to. It will be clearly understood that unless otherwise referred to the following considerations are confined to the fundamental pure iron-carbon alloys.

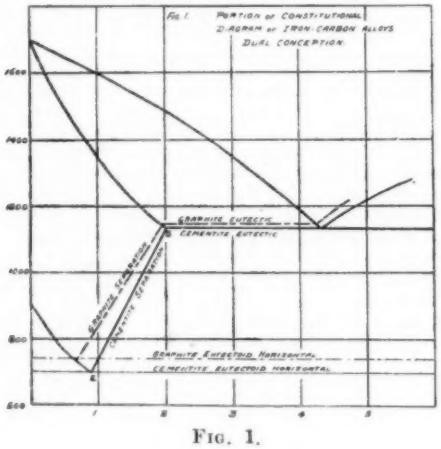


Fig. 1.

Broadly speaking, there are two modern views held on the mechanism of the graphitisation phenomena. The older of these two views considers the iron-carbon alloys as capable of solidifying when cooling down from the molten state along two distinctly different lines. Under ideal conditions principally slow cooling, during which ample time is allowed for the various constitutional changes to take place to completion, the solid alloys at the temperature of the completion of the solidification consist of two constituents, namely graphite and a solid solution of graphite in iron, which is well known as Austenite. Under conditions of comparatively rapid cooling the constituents existing in the solid alloys immediately after the completion of the solidification period are the solid solution austenite and the carbide of iron known as cementite. This conception, known as the dual conception of a stable and meta-stable (or semi-stable) system of constitution, is embodied in the well-known constitutional diagram. (Fig. 1.) In this diagram, dotted lines represent the stable conditions in which solid alloys at the eutectoid temperature consist of austenite and austenite-graphite eutectic and the meta-stable conditions are represented by the continuous lines in which the constituents at the eutectic temperature consist of austenite and austenite-cementite eutectic.

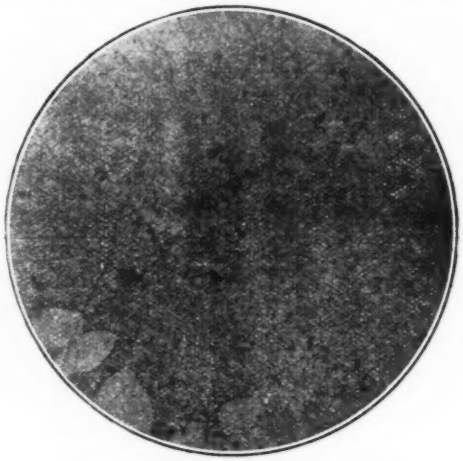


Fig. 2.—Structure of Swedish Iron having the Appearance of Graphite — Austenite Eutectic.

Condition of Carbon in Solution in the Liquid Alloys.

The assumption of a complete stable system of iron and graphite in accordance with the above demands the conditions that the carbon is in solution as graphite and not necessarily as the carbide. This was practically the original suggestion of Roozeboom.[1] Roozeboom finally abandoned his further suggestion that the formation of the carbide of iron resulted from a reaction between the solid solution and the graphite at a period subsequent to the formation of the eutectic, and agreed with the dual conception substantially as above.

Up to the present no attempt to retain the stable state at the eutectic temperature by the method of rapid quenching of the alloys has been successful in retaining the austenite-graphite eutectic. In all cases the two phases separating out under these conditions have been found to be austenite and cementite the carbide of iron. These are the constituents of the eutectic of the meta-stable system. The explanation of this by Continental workers is that undercooling always takes place at least down to the eutectic temperatures resulting in solidification according to the meta-stable conditions, and the graphite found in cast iron

* A Paper read before a meeting of the Birmingham Branch of the Institute of British Foundrymen, Mr. T. Vickers presiding.

[1] J.I.S.I., 1900, No. 2, page 311.

results from the dissociation of this primarily formed carbide.

The impossibility of the existence of an austenite-graphite eutectic has not yet been finally disposed of. Austenite-graphite structures are frequently met with having all the appearances of a characteristic eutectic structure. A case has been reported by Levy and a photograph of such a structure met with in one of the author's own experiments on a hypo-eutectic Swedish iron of the following composition is given in Fig. 2:—Tot.C., 3.40: Gr., nil; Si, 0.37; Mn., 0.30; S., 0.65 per cent., and P., nil.

The structure shown in Fig. 3 was obtained in a sample of this material melted at a very high temperature in the muffle of a Brayshaw injector

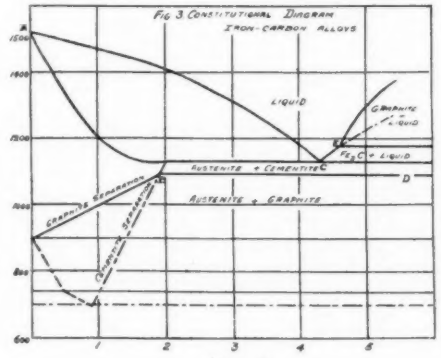


Fig. 3.

furnace, and allowed to cool slowly in the crucible in the atmosphere. The mass of the sample was 300 grammes.

Further evidence on which the dual conception is based is to be found in the fact that the hyper-eutectic alloys containing carbon in excess of the eutectic percentage deposit graphite, which rises to the surface of the molten metal immediately on commencing to solidify, producing the well-known "Kish" phenomena. These phenomena have been amply substantiated, and superficially would appear to support the belief that the carbon is dissolved in the molten iron as graphite.

It has already been mentioned that the rapid quenching of the molten alloys from all temperatures down to the final solidification point results in the production of austenite, austenite-cementite structures with no free carbon. This fact is interpreted as indicating that the carbon is in solution in the liquid alloys as the carbide of iron probably identical with cementite, and that its formation in the quenched alloys is the normal state of affairs and not necessarily the result of undercooling. Most British metallurgists have adopted this view, and it has been confirmed recently by Honda[2] and Cesaro.[3] Under this conception the carbide of iron is the stable phase down to temperatures slightly below the final solidification range, and the subsequent appearance of graphite is due to the breakdown of these austenite, austenite-cementite structures at lower temperatures.

The explanation of the formation of kish in the liquid hyper-eutectic alloys under these conditions is met in several ways. It is primarily suggested that this may be due to the presence of such elements as silicon.

This is admittedly quite a plausible explanation, as almost all the alloys which have been used in investigations contained at least traces of such impurities. This suggestion has been largely made by Hatfield. It must be remembered, however, that Professor Howe called attention to the difficulty of preserving the hyper-eutectic carbide in alloys without at least a trace of manganese. Dr. Hatfield agreed with this, and the writer has never had the opportunity of obtaining hyper-eutectic cementite in alloys free from manganese.

A somewhat different suggestion has been made by Edwards,[4] Gonterman, Andrews[5] and others. These workers assume that cementite is the stable phase down to temperatures somewhat below the eutectic temperature, approximately 1,100 deg. C., according to Andrews. This is illustrated in the diagram, Fig. 3, in which the lower limit of stability is indicated by the line B.D. The formation of kish has been met by Edwards by the assumption of an upper limit of stability of the carbide, as indicated by the line C.E. in the diagram, Fig. 3.

According to this assumption, at temperatures and concentrations but little in excess of those of the eutectic alloy, the cementite carbide is stable, and crystallise from the molten liquor. The break at the point in the liquidus curve would under these circumstances indicate a reaction of the type $Fe_3C \gtrless$ graphite and molten liquid according as to whether the alloy is being heated or cooled.

The existence of such an upper limit has not yet been demonstrated by experiment, and in fact the experiments of Ruff and Goecke and Hannemann into the hyper-eutectic regions of these alloys have shown no break in the liquidus curve corresponding to such a reaction.

The stupendous difficulties involved in experiments in this region, however, have so far prohibited the use of sufficiently sensitive and accurate methods necessary to detect such a point.

The diagram propounded by Upton[6] has often been referred to, and is another case which has the merit of avoiding the dual conception referred to earlier. Whilst this diagram involves further complexities and postulates the existence of certain complex carbides other than Fe_3C, the method of dealing with the alloys at the solidification point is worthy of reference here. In this conception the phases separating out from the hyper-eutectic alloys under stable conditions are considered to be austenite and graphite. In the light of this diagram the structures of white cast iron and quenched cast iron are due to undercooling, and consist of austenite and under-cooled liquid. The production of free carbon during subsequent annealing is presumed to be due to reactions which were otherwise suppressed during solidification.

There is no doubt that the weight of the evidence is in the favour of regarding the carbon as existing in the liquid iron as the carbide of iron, and for this reason the omission of the lines indicating the graphite-austenite equilibrium

Fig. 1.—Swedish Iron, showing Cementite Needles Deposited from Solid Solution.

from the upper portion of the diagram is the most rational way of interpreting the facts as we now know them.

The possibility of the existence of free graphite, either suspended in the molten iron or in some colloidal form, as has been frequently stated by recent workers, must be dismissed as entirely without proof, evidence or foundation. In fact, the whole mass of evidence plainly negatives such suggestions.

[2] J.I.S.I., No. 2, 1920.
[3] J.I.S.I., No. 1, 1919.
[4] Physico-chemistry of Steel, London, 1914.
[5] Carnegie Memoirs, J.I.S.I., 1917.
[6] J. Phys. Chem., 1908-12 and 1909-13.

Temperature at which Graphite Commences to Form.

The fact that no well-defined arrest point corresponding to the precipitation of graphite is to be found in the cooling curves of the iron-carbon alloys is in a large measure responsible for the conflicting views as to its formation. Experience conclusively demonstrates that the formation of graphite is continuous for a considerable temperature range below the solidification, which at once explains the absence of anything in the nature of a definite arrest point on the cooling curves.

By means of quenching experiments the temperature of the commencement of graphitisation has been shown by various investigators. From such experiments Andrews concluded that graphitisation commenced after the final solidification point at temperatures between 1,150 and 1,100 deg. C. Honda,[7] placed this temperature somewhat lower between 1,130 and 1,050 deg. C. The recent experiments of Northcott[8] with ordinary grey irons place the temperature at 1,145 to 1,000 deg. C. These observations are in agreement with the diagram of the Gonterman-Edwards type, and the conclusions of Cesaro[9] from certain mathematical considerations.

Experimental evidence definitely places the commencement of graphitisation and the stability of the carbide at some distance below the solidification point at least 5 or 10 deg. C.

The Formation of Graphite from the Primarily Formed Carbide.

There is now to consider the formation of graphite as found in all commercial grey cast irons

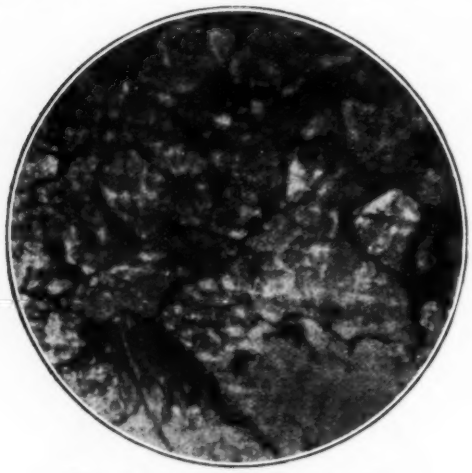


Fig. 5.—Austenitic Structure in Quenched Grey Cast Iron.

from the stable structure austenite and cementite. The general view is that the graphite arises from the dissociation of this primarily formed carbide according to the rate of cooling in these lower ranges of temperatures.

Here, again, there are various opinions as to the exact nature of this dissociation. The simplest case is the assumption of the direct dissociation of the carbide into ferrite and graphite in accordance with the equation:—

$$Fe_3C = 3Fe + C.$$

An alternative suggestion has been made that the cementite carbide dissociates into graphite, and the solid solution of carbon in iron as represented by the equation:—

$$Fe_3C = C + \text{solid solution of C in Fe.}$$

A totally different suggestion has been put forward by Honda and his various Japanese collaborators in which the dissociation of the carbide is the result of a reaction between the dissolved CO_2 gas and the carbide. This suggestion will be dealt with under a separate heading.

The two former views arise out of the difficulty of explaining the presence or absence of free ferrite. If the former view is accepted it would appear inevitable that all alloys containing free graphite must contain free ferrite. It is known from experience that this is not the case, and for this reason the second view more nearly fits in with the facts as they are known. Under these circumstances free ferrite arises from the secondary precipitation of graphite from the saturated solid solution.

A very brief picture of the sequence of events in the solidification of liquid cast iron can now be made. The liquid alloy, consisting of a solution of carbide of iron in iron solidifies as a stable mixture of the austenite solid solution and the austenite carbide eutectic. This condition is stable at least down to a temperature in the region of 1,100 deg. C. Then, according to the rate of cooling, the free carbide of the eutectic dissociates into graphite and a further quantity of the solid solution.

We have now to consider what happens to the solid solution, or austenite, in cooling down from the eutectic temperature. As the temperature gradually falls, the solid solution becomes saturated with respect to carbon, and the line SE in the diagram, Fig. 1, shows the extent of the decrease in concentration of the saturated solid solutions with a decrease in temperature. The excess carbon in solution in pure iron carbon alloys is deposited in the form of carbide needles which are very familiar in case-hardened steel samples, and are readily seen in the primary austenite areas of hypo-eutectic white irons. An example of this is illustrated in Fig. 4, showing the cementite needles in a slowly cooled big iron. It is quite rational to assume that the secondary carbide deposited by the solid solution decomposes in a like manner to the primary carbide already referred to. This does not help to explain the formation of free ferrite, as under these circumstances it will be appreciated at once that the structure at the pearlite change point would consist of purely graphite and pearlite.

If the reverse process of heating up specimens of grey cast iron is considered, it has been frequently shown that the free graphite redissolves in the cast iron. This phenomenon was shown by Mr., now Sir Robert, Hadfield[10] in connection with malleable cast iron, and further amplified by Dr. Hatfield[11] and the writer.[12] Details of a further experiment on this subject, conducted by the writer, are worthy of reference here. In this experiment small ½ in. square by 3 in. long bars of a grey hematite were heated to a temperature of 1,015 to 1,025 deg. C. in an exhausted tube. The photograph, Fig. 5, shows the microstructure of the bar quenched in water from 1,025 deg. C., after maintaining at this temperature for one hour, and one after slow cooling without quenching. The analyses of the various specimens are given in the following table:—

	Original.	Quenched.	Slow cooled.
	Per cent.	Per cent.	Per cent.
CC. ..	0.17	0.90	—
Gr. ..	2.93	2.20	—
Tot. C...	3.10	3.16	3.15
Si ..	1.18	—	—
Mn ..	0.26	—	—
S ..	0.077	—	—
P. ..	0.04	—	—

The quenched sample showed a distinctly austenitic structure composed of polygonal austenite grains with the undissolved graphite presumably existing round the grain boundaries. The extent of the re-absorption of the graphite in this case amounts to 0.73 per cent., and in a further experiment of 6 hours duration the combined carbon figure in the quenched sample was 1.02 per cent. indicating a re-absorption of graphite to the extent of 0.85 per cent.. Prolonged heat treatment experiments at temperatures in the neighbourhood of 1,000 deg. C. have failed to bring about the absorption of graphite in amounts exceeding the amount required to satisfy the saturated solid solution at this particular temperature, and such experiments have failed to bring about the reproduction of the free cementite carbide. Such experiments have been repeatedly con-

[7] J.I.S.I., No. 2, 1920.
[8] I.B.F. Proc., 1924.
[9] J.I.S.I., No. 1, 1919

[10] J.I.S.I., 1894, No. 1, page 156.
[11] J.I.S.I., 1906, No. 2, page 162.
[12] J.I.S.I., 1917, No. 2, page 125.

firmed, particularly recently by American workers, notably R. S. Archer[13] and Merica,[14] and they serve to demonstrate that a portion of the graphitic carbon (not necessarily in the so-called temper-carbon form) is directly soluble, without the intervention of the free carbide stage forming presumably the austenite solid solution.

From experiments of this nature it is therefore quite rational to conclude that the solid solution is capable of depositing graphite directly without the intervention of the intermediate stage free carbide. This being the case the presence of free ferrite is capable of simple explanation as resulting from the reduction in concentration of the solid solution due to the direct deposition of graphite, the solid solution after passing the pearlite transformation resolving itself into ferrite and pearlite.

American workers apparently still lean towards the dual conception of the constitution of these alloys previously referred to, and consider that the solid solution resulting from the re-absorption of the graphite is different in character to the normal austenite solid solution, which has been regarded as the solid solution of carbide of iron in iron. To such an extent is this view held in America that they have suggested the title Boydenite for the former solid solution. It is only right to state here that recent American work leads to the assumption that "the presence of silicon is a requirement of Boydenite," Schwartz, Payne & Gorton,[15] and, indeed, the writer's experiments and most others have been conducted on irons containing at least small quantities of silicon. In the first place it does not appear necessary to postulate the existence of two solid solutions, for if cementite carbide is unstable in the free state, it might be expected to be equally if not more unstable in solution. Secondly, in so far as foundrymen are concerned, as silicon is invariably present in the alloys with which they are called upon to deal the necessity of the presence of silicon to ensure the precipitation of graphite in this manner with the concurrent formation of ferrite is not of much importance.

Before leaving this section of the subject we have to consider the recent suggestion of Honda that the production of graphitic carbon is due to the catalytic action of the dissolved gases on the free carbide. The mechanism of this suggested action is briefly stated as follows:—As the temperature of the specimen falls below the melting point a minute quantity of free CO_2 co-existing with CO soon reacts on the free cementite and produces CO by the equation:—

$$Fe_3C + CO = 2CO + 3Fe$$

The alteration in equilibrium conditions by the disappearance of free CO_2 as a component causes further dissociation of CO in accordance with the equation:—

$$2CO = CO_2 + C.$$

reproducing the CO_2 which again reacts with the cementite, thus maintaining the continuity of events.

The catalytic action of this nature is admittedly only a suggestion, and whether or not it is a correct picture of the actual mechanism of graphitisation direct experiment only can decide.

On consideration it will be seen at once that this suggestion refers solely to the manner of the dissociation of the free carbide, and even this suggestion is open to the difficulty of explaining the presence of free graphite in the presence or absence of free ferrite.

Apart from this, the suggestion of this catalytic action is open to the serious objection that for its reception and continuation it requires certain well defined limits of temperature and ratio between the amount of CO_2 and CO present in the iron. It does not seem reasonable to expect that the ratio of CO_2 to CO present in these iron-carbon alloys prepared in all varieties of methods should be invariably within these limits, and yet under correct cooling conditions graphite is invariably produced, whatever the source of the iron-carbon alloy.

The formation of graphite by the intervention of these catalytic actions is merely a suggestion, and has not been definitely proved. In the author's opinion it is very unlikely that this is a reasonable explanation and until further evidence either way is forthcoming it does not affect the conception we have tried to draw from the facts as we know them at present.

Summarising these facts, we must admit that the evidence is in favour of regarding the carbon in solution in the liquid metal as the carbide of iron. This carbide of iron is the stable phase deposited on passing the temperature of the final solidification point and forming a constituent along with the solid solution of the eutectic. On further cooling down the carbide dissociates into graphite and the solid solution, which in its turn is capable of depositing graphite directly.

On passing the eutectoid point the solid solution resolves itself into pearlite ferrite and graphite according to the extent of the dissociation of both the carbide and the solid solution, which, of course, depends upon the rate of cooling.

DISCUSSION.

The President said the meeting of the Branch was held in conjunction with the Staffordshire Iron and Steel Institute, and he hoped that if any members of the Iron and Steel Institute were present they would take part in the discussion as freely as the members of the local Branch of the Foundrymen's Institute. The problem with which Mr. Hurst had dealt was one which had exercised the minds of metallurgists in this country and in America, and his contribution would be read with interest and appreciation. There was no doubt many would not agree with some of the arguments advanced, and healthy criticism would be welcomed.

Mr. Arthur Marks described the Paper as an excellent explanation of the modern work connected with the graphitisation of cast iron. As to the explanation with regard to free ferrite, he did not see any need for worry about free carbon being formed prior to the formation of Fe_3C. In his opinion the amount of carbon present, 4.3 per cent., was insufficient to saturate all the iron, and therefore the possibility of free ferrite being present was quite explicable from a chemical point of view. The question of the decomposition of carbide by CO_2 and CO was bound up with the question of the dissociation of CO_2 into CO. He had not the figures by him, but, speaking from memory, he thought the percentage of CO_2 which was present at the temperature of the reactions, 1,150 to 1,100 deg., was not sufficient to account for the reaction $Fe_3C+CO=2CO+3Fe$. He thought the degree of dissociation of the CO_2 to CO would be too high, and that the excess CO would not render that reaction so comfortable as it could be written on the blackboard. To-day there were very few castings which were made with graphite as high as 4.3 per cent.; in practice one would be immediately in trouble in various directions. With regard to centrifugal cast iron, he did not think the speeds of rotation were sufficiently high to give the separation in view of the thicknesses involved and the rapidity of cooling. As a matter of practical politics he considered there could be no practical separation of the graphite under the speeds used and the rapid cooling when casting under these conditions. No doubt it was a matter for experiment; he was only giving his own personal view of the case.

Mr. E. Longden said Mr. Hurst had referred to the quenching of a stream of molten iron by immersion in iced brine, and had pointed out that no graphite was discovered in that metal. To his mind that was no proof that graphite did not exist in the molten iron before solidification. He thought it did, and that by quenching the iron from a high temperature they exerted a pressure, preventing the formation of graphite. In the case of mottled iron, which was on the border line of white iron and grey iron, they again saw two conflicting forces. The graphite was attempting to expand, and the white iron, the white matrix, refused to allow the graphite to expand. He asked Mr. Hurst whether he would think it possible to produce a casting weighing about 8 cwt., 17 in. or 18 in. in diameter and 13 in. or 14 in. deep, without any attempt to feed it. If he informed the lecturer that he (Mr. Longden) had been able to secure that mass of iron absolutely solid without attempt to feed, how would he explain that con-

[13] Amer. Mining and Met Engs., February, 1920.
[14] Amer. Bureau of Standards, No. 129.
[15] Amer. Inst. Min. and Met. Engs., August, 1923.

XUM

tradictory conclusion, because they were given to understand that there was liquid shrinkage in grey iron. In his (the speaker's) opinion there was none. What shrinkage there was was due to gases. The question of the formation of kish went some way, in his opinion, to prove the theory that graphite was present in iron in the molten state. All the graphite did not come to the top. There were all sorts of pressures and tensions which prevented its doing so. His view was that kish in a very high silicon iron was being formed all the time and the metal was not solidified. Take acid-resisting metal with a silicon content of about 15 per cent. In that case they found the cupola after blowing down a mass of graphite flakes which were being formed while the metal was molten.

Mr. J. B. Johnson proposed a vote of thanks to Mr. Hurst for his address, and Mr. F. C. Edwards, in seconding, contended that carbon dissolved in iron in the same way as salt or sugar dissolved in water. There were good grounds for holding that at a high temperature the carbon in cast iron was in solution. It was not suspended, it was dissolved, and as they lowered the temperature the carbon was thrown out. The Paper went a long way towards popularising the most advanced knowledge, and anyone striving to popularise advanced knowledge was performing a great work.

The President having added an expression of his appreciation of the Paper the resolution was heartily agreed to.

The Author's Reply.

Replying upon the discussion, Mr. Hurst referred to the suggestion made by Mr. Marks that the speed of centrifugal casting was hardly sufficient to separate the graphite. Mr. Marks rather implied that the casting was thin, but he (the lecturer) had dealt with centrifugal castings which could not be so described. For example, a casting with a radial thickness of, say, 12 in., was hardly thin, and a good many castings had been made with that thickness in which there had been no graphite separation. The remarkable thing was that there had been a considerable amount of sulphide separation, practically the whole of the sulphide segregating to the inside surface of the casting. The difference in the specific gravities of manganese sulphide and graphite is so great that one would expect graphite freely to separate before the sulphide. This is not the case. All varieties of grey pig-iron in Great Britain had been used in the production of these centrifugal castings, and they had never yet found a pig-iron which was of such a nature that the graphite would separate out in the centrifugal process. He was inclined to think that the structures which appeared to be Austenite graphite eutectic structures were not eutectic structures at all, but were structures brought about by a state of affairs in the cooling down, in which the graphite was deposited from the solid solution in this very finely divided form. The rate of cooling had been such that there had been very little opportunity for any of the graphite plates to congregate together and to present themselves more or less in the characteristic form of graphite plates. In other words they should be regarded as transition stages. They did not know just how much excess over the eutectic percentage of carbon was necessary to bring about the phenomenon of kish. They did not notice the phenomenon of kish in any ordinary commercial foundry iron, except the silicious irons. It was only when carbon was in excess of the eutectic percentage that this phenomenon was observed. Mr. Longden's supposition that graphite may exist as such in the liquid iron before solidification is answered in a very practical manner by the experience with centrifugal castings.

Mr. Longden's other point is rather outside the scope of the paper. There is no doubt that such a casting can be produced perfectly sound without any attempt to feed it. Presuming that the casting is cylindrical the best way is to cast it centrifugally. The other common way is to provide a shrinkage head. All the other alternative methods can probably be summarised in the following words: to pour the casting in such a manner that the majority of the liquid shrinkage of any portion of the metal already in the mould has taken place before the next portion of metal enters the mould.

Institute of British Foundrymen.

LANCASHIRE BRANCH.

The annual meeting of the Lancashire Branch was held on April 4 at the Municipal College of Technology, Manchester, Mr. R. A. Miles presiding.

The Secretary's annual report, read by Mr. T. Makemson, stated that the Branch consisted of 94 members, 191 associate members, six associates, and eight subscribing firms, a total of 299. During the year 34 new members had been admitted and 21 names had been removed from the list owing to resignation or other reasons, making a net increase of 13. The attendance at the meetings had seldom been less than 80, and on one occasion reached 120. The Branch had lost one of its best known members by the death of Mr. W. H. Cook. Visits had been paid to the works of five firms, the L.M. & S. Railway at Horwich, Messrs. Howard & Bullough, Accrington, the Sheepbridge Coal & Iron Company, the Richmond Gas Stove and Meter Company, Limited, Warrington, and Messrs. Ruston & Hornsby, Reddish. On every occasion the attendance was about 100. The annual dinner held on February 7 was attended by 120 members and ladies.

The outstanding event of the year had been the formation of the Junior Section. The inaugural meeting, held on November 15, was attended by about 240. Meetings had since been held monthly; there had been two works' visits, and other visits had been arranged for during the summer. The Section was managed by a committee elected by the members of the Section, together with representatives of the Senior Section, and was under the presidency of Mr. R. W. Stubbs.

Several members of the Branch held important positions on various technical and research associations. Mr. Oliver Stubbs was vice-chairman of the British Cast-Iron Research Association, and Messrs. Haigh, Dawson and Jolley were members of the Council of that body. Mr. Jolley also represented the Branch on the Institute's Test Bar Committee, and he had been appointed a member of the British Engineering Standards Association's Committees on Test Bars and Grey Iron Castings, and of the Non-Ferrous Metals Research Association's Committee on Die Castings.

The Branch Council had held eleven meetings, and there had also been a number of sub-committee meetings. All these had been presided over by the Branch-President, Mr. R. A. Miles.

The balance-sheet for the year ending December 31, 1924, showed that subscriptions to the amount of £391 2s. 6d. had been received and forwarded to the general office. The Branch was entitled to one-third of this amount, but only £75 had been asked for and received. Including bank interest 6s. 11d., and the balance in hand at the beginning of the year, the total income was £92 15s. 2d., and the total expenditure was £90 0s. 1½d.

A motion that the meetings be held on Saturday evening instead of Saturday afternoon was proposed by Mr. Prescott and seconded by Mr. Key. On a vote being taken it was lost by a large majority. A vote of thanks to the retiring officers was passed, on the motion of Mr. Prescott.

The election of officers and committee for the next session resulted as follows:—President, J. Masters; senior vice-president, S. G. Smith; junior vice-president, J. S. G. Primrose; secretary, T. Makemson; auditors, W. H. Grandison and R. P. Layfield; Branch Council (three vacancies): G. Barnes, E. E. Grimwood and A. Hill; Delegates to General Council: A. L. Key, J. S. G. Primrose, R. A. Miles, J. Hogg and H. Sherburn.

Mr. Priestley suggested that a rule be made that no member shall hold more than one office. In his opinion those who filled some position took more interest in the work of the Branch, and the greater the number of them the better for the Branch.

Mr. McLachlan suggested that a copy of the balance sheet be printed and circulated to the members.

The Chairman asked that the suggestions be embodied in writing and submitted to the Branch Council, who would give them consideration.

The Improvement of Cast Iron by Alloy Additions.*

By E. Piwowarsky, Aix-la-Chapelle.

(Transactions of the Iron Founders' Institute of the Technical High School, Aix-la-Chapelle.)

Introductory Note.

[In this Paper metric measurements have, for the convenience of British readers, been converted into British units. In Table IX the transverse strength has been converted from the Continental rupture modulus in kg/mm² to breaking load on the same bar (40 cm. or 15.8 in. centre and 2 cm. or 0.79 in. diam.). It will be noted that this corresponds closely with the I.B.F. bar S, 12 in. centre and 0.875 in. dia. Tensile strength has also been converted, but the shock test in mkg/cm² has been left unchanged, as the nature of the machine used is not stated, and conversion would serve no useful purpose. This also applies to Table X, and in Table XI the length of the bar is not quite clear, but has been taken as 30 mm.

[We acknowledge the help given in the matter of converting the numerous tables into British standards by Mr. Neath of the British Cast Iron Research Association.—EDITOR.]

Efforts to improve the quality of cast iron by the addition of certain special elements date from the beginning of the present century. For the most part, however, they were desultory efforts wanting in systematic coherence and originating rather from the impulse towards experimental inquiry on the part of individual professors or metallurgists than from the serious need for effort in the matter of economic competition. The general conditions for contracts no doubt contained stipulations as regards mechanical properties which could be fulfilled by the foundries without any

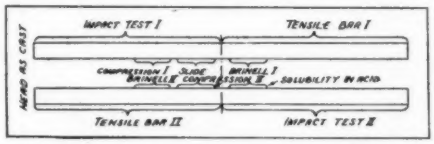


FIG. 1.—ARRANGEMENT OF TEST PIECES.

particular trouble. The requirement of good machinability came first. In the course of the last ten years, during which the introduction of science into practical work has made such remarkable progress, both consumer and manufacturer gradually came to recognise that grey pig-iron was a material the quality of which was still capable of the most extensive improvements. Thenceforward more careful efforts were made in regard to desulphurisation, the chemical composition was more closely adapted to the purpose of the castings, the casting and mould temperatures were more thoroughly supervised, the cooling conditions of the solidifying metal were more suitably regulated, more attention was paid to the moulding materials, and by a more suitable distribution of the sand, particularly in the production of complicated castings, it was sought to obtain a metal more free from defects. Owing to the more unfavourable market conditions existing after the war and the growing competition of steel castings, which had been more rapidly adapted to the greatly increased qualitative requirements of engineering, automobile and boiler construction, etc., the necessary emphasis was simultaneously given to the question of quality in the grey iron foundries. Combination processes serving to enhance the quality were increasingly employed in them. The importance of the reverberatory melting furnaces has at length been given due recognition. Great interest is also taken in the electric furnace, which is now increasingly employed in the refining of grey iron. No doubt its place in the grey iron foundry is still debated, but the stress of economic circumstances does not abate and keeps interest in the solution of this question alive.

In view of these new conditions it can readily be understood that the efforts to attain a further increase in the mechanical quality figures by means of special elements would be renewed. Recently O. Smalley[1] investigated the influence of a number of special elements on the properties of a number of technical cast irons (ordinary and cylinder iron), and noted, in part systematically, the silicon content simultaneously present in the iron tested. In these experiments a copper addition of about 0.5 per cent. exercised a feeble influence as regards increasing the hardness, while all the other properties, as well as the structure, showed no change worthy of note. A small nickel addition (0.5 per cent.) produced refinement of the graphite separation without alteration in hardness. On the other

FIG. 2.—TENSILE TEST PIECE (DIMENSIONS IN M/MS).

hand, chromium caused a sensible increase of hardness and transverse strength. Molybdenum operated only from 0.5 per cent. upwards in the sense of a general improvement of quality, with a slight decrease of hardness. Tungsten had an effect similar to that of molybdenum, but to a less extent. Cerium, uranium, calcium, vanadium and zircon exercised no practical calculable influence on the mechanical and physical properties of the different irons examined, and the same applies also to aluminium and magnesium. Aluminium naturally made the iron rather softer, while magnesium hardened it.

Since 1920 the writer has been systematically engaged in investigating the effect of special elements and has repeatedly published reports[2] on his experiments. Now that the first lengthy series of systematic experiments has been concluded, it appears desirable to give a short summary of the results, taking into account the reports already published. Its appearance now in a summary form, instead of in separate contributions devoted to each special element, is due—as will be explained later—to the fact that the improvement of cast iron appears to the writer, from the experimental results recently obtained, to be of rather less practical importance than was originally ascribed to it.

For the whole series of experiments a Swedish pig-iron was employed throughout with:—Total C,

FIG. 3.—MICRO OF AN ALLOY WITH 2.75 PER CENT. SI AND 0.5 PER CENT. W.

4.01; Si, 0.04 to 0.06; Mn, 0.13 to 0.14; P, 0.018 to 0.02, and S, 0.011 to 0.02 per cent. In every case the melting furnace employed was a gas-fired crucible furnace, except that the experiments on the effect of vanadium were carried out in a coke-fired crucible furnace. For each of the individual

* Translated from "Stahl und Eisen."

[1] "Foundry Trade Journal," 26 (1922), p. 519-23; and 27 (1923), p. 3-6.

[2] "Stahl und Eisen," 40 (1920), p. 1306; 43 (1923), pp. 967 and 1491.

experimental meltings 4 to 6 kg. (8.8 to 13.2 lbs.) of the Swedish iron was melted down, the temperature being raised to nearly 1,400 deg. C.; the iron was then alloyed with the requisite amount of silicon or iron alloys, allowed to cool to about 1,300 deg., and then cast upright in dried smoothed moulds, which were standing ready, into round bars 20 mm. (0.79 in.) dia. and 650 mm. (25.5 in.) in length. In order to make allowance for the effect of the silicon content already present in the technical cast iron, three lengthy series of experiments were made, in which it was sought to make the silicon content 1, 1.75 and 2.75 per cent. respectively. Within these main series, which will here be uniformly designated Series I, II and III respectively, the content in special elements was now correspondingly altered. Below are shown briefly the elements which were dealt with, the nature of the special alloys used being indicated in parentheses:—

(1) Aluminium to 0.1 per cent. (alumino-thermic carbon-free low alloyed ferro-aluminium with about 6 per cent. aluminium).

(2) Titanium to about 1 per cent. (alumino-thermic ferro-titantum with 20.9 per cent. metallic titanium).

(3) Nickel to 2 per cent. (cube nickel with 96.65 per cent. Ni).

(4) Chromium to about 0.5 per cent. (ferro-chromium with 48.46 per cent. Cr and 1.06 per cent. C).

(5) Nickel chromium simultaneously, in contents as indicated under (3) and (4).

(6) Vanadium to about 1 per cent. (ferro-vanadium with 62.4 per cent. V and 0.05 per cent. C).

(7) Tungsten to about 0.5 per cent. (ferro-tungsten of 82.8 per cent. W and 0.68 per cent. C, alloyed down with soft iron to 15.4 per cent. W).

(8) Molybdenum to about 1 per cent. (ferro-molybdenum with 43.6 per cent. Mo and 0.91 per cent. C).

(9) Tungsten vanadium (tungsten content as under (7), vanadium content to 0.25 per cent.).

(10) Molybdenum vanadium (molybdenum content as under (8), vanadium content to 0.25 per cent.).

The cast test bars were subjected to transverse test with a distance between supports of 40 cm. (15.8 in.) = 20 × diameter, the skin being left on. The test pieces served in part for ascertaining the specific shock energy, and in part for the tensile, hardness and compression tests, the individual test bars always being arranged as in Fig. 1 in order to obtain comparable values. In the Tables 1 to 8 only unexceptionable and closely approximating mean values from at least two or three tests were included. Fig. 2 shows the form of the tensile bars employed. Cylindrical samples in which diameter=height=18 mm. (0.72 in.) (with vanadium=20 mm.) (0.79 in.) were used in the compression test.

The impact tests were carried out on the unnotched bars of 20 mm. (0.79 in.) dia. with the skin left on, and the Brinell hardness tests with a 10-mm. ball, P=1,500 kg. (with vanadium a 5-mm. ball and P=500 kg.).

Table I.—*Tests with Aluminium.*

Series	Al Added Per cent.	Al found Per cent.	Si. Per cent.	C.C. Per cent.	Gr. Per cent.	Transverse load in lbs.	Deflection in ins.	Compression, tons per sq. in.	Shock test.	Brinell hardness.
I	—	—	0.99	1.64	1.90	625	0.24	62.2	1.04	256
	0.025	0.022	1.04	1.55	1.92	668	0.24	58.5	1.14	233
	0.05	0.042	0.97	1.30	2.11	732	0.25	53.8	1.27	215
	0.10	*0.082*	*1.08*	*1.09*	*2.24*	*765*	*0.25*	*51.5*	*1.30*	*197*
II	—	—	1.58	1.35	2.19	558	0.31	54.2	1.01	221
	0.025	0.022	1.62	1.18	2.23	600	0.31	49.2	1.26	197
	0.05	0.042	1.59	0.90	2.45	645	0.33	45.4	1.33	201
	0.10	*0.083*	*1.68*	*0.57*	*2.71*	*702*	*0.35*	*48.7*	*1.51*	*164*
III	—	—	2.69	0.71	2.88	459	0.38	43.5	1.29	141.1
	0.025	0.022	2.75	0.57	2.90	484	0.41	48.5	1.36	136.1
	0.05	0.040	2.72	0.40	2.98	510	0.41	35.0	1.40	122.9
	0.10	0.082	2.67	0.33	3.00	594	0.43	29.5	1.41	118.0

Table II.—*Tests with Titanium.*

Series	Si.	Ti. Added	Ti. found	C.C.	Gr.	Transverse load in lbs.	Deflection in ins.	Compression, tons per sq. in.	Brinell hardness.	Shock test.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.					
I	1.02	—	—	1.63	1.89	625	0.23	62.5	263	1.1
	1.22	0.12	0.038	1.35	2.53	530	0.21	58.5	225	1.1
	1.15	0.24	0.094	0.81	3.03	614	0.27	53.8	189	1.7
	1.08	0.58	0.327	0.92	3.10	635	0.25	52.2	197	1.3
	1.08	*1.16*	*0.516*	*0.98*	*2.82*	*854*	*0.28*	*62.0*	*215*	*1.5*
II	1.71	—	—	1.28	2.24	566	0.24	57.5	216	0.9
	1.65	0.12	0.066	0.70	3.29	470	0.26	29.5	108	1.4
	1.94	0.24	0.119	0.69	3.25	488	0.24	40.5	137	1.6
	1.73	0.58	0.251	0.63	3.25	522	0.22	42.2	148	1.3
III	2.54	—	—	0.67	2.89	460	0.31	41.5	141	1.3
	2.69	0.12	0.068	0.30	3.32	412	0.27	25·8	97	1.2
	2.69	0.24	0.118	0.56	3.19	455	0.26	35.0	118	1.1
	2.66	*0.58*	*0.353*	*0.41*	*3.22*	*720*	*0.24*	*53.0*	*164*	*1.3*

Table III.—*Tests with Nickel.*

Series	Si.	Ni.	C.C.	Gr.	Transverse load in lbs.	Deflection in ins.	Compression, tons per sq. in.	Brinell hardness.	Shock test.
	Per cent.	Per cent.	Per cent.	Per cent.					
I	0.94	0.0	1.36	2.63	450	0.27	34.0	111	1.15
	0.92	0.49	1.33	2.64	625	0.29	46.7	150	1.30
	0.94	1.06	1.27	2.70	585	0.28	44.6	138	1.42
	0.96	1.51	1.13	2.79	542	0.30	42.7	124	1.12
	0.91	1.97	1.08	2.87	470	0.27	38.8	118	0.92
II	1.60	0.0	1.13	2.69	420	0.29	34.9	107	1.24
	1.61	0.50	1.07	2.67	592	0.31	46.0	143	1.27
	1.63	1.08	1.01	2.73	552	0.30	47.0	139	1.19
	1.61	1.50	0.90	2.81	538	0.28	40.7	126	1.16
	1.63	2.07	0.73	2.96	475	0.28	42.2	123	1.21
III	2.76	0.0	1.53	1.56	622	0.25	53.5	184	1.01
	2.72	0.49	1.46	1.60	*780*	0.27	76.2	*224*	1.24
	2.72	0.96	1.43	1.57	*715*	0.25	71.2	*215*	1.19
	2.72	1.49	1.43	1.62	*697*	0.25	70.0	*209*	1.10
	2.71	1.98	1.40	1.62	*682*	0.25	66.5	*205*	1.01

RESULTS OF THE TESTS.

A.—Effect of Aluminium.

In the low silicon Series I and II an aluminium content of 0.02 to 0.08 per cent. in the casting

effected an increase in transverse strength up to 25 per cent., with constant or even somewhat increased deflection, and an increase in the specific shock energy of 25 to 50 per cent. Hardness and compressive strength declined actually by about 20 to 30 per cent.

In the high-silicon Series III the transverse strength and specific shock energy are only slowly increased by the addition of aluminium, while as regards the other properties, what is stated in Series I and II also applies (*cf.* Table I).

The effect of the aluminium is mainly attributable to its powerful graphitising action.

B.—Effect of Titanium (Table II).

(1) Titanium influences the formation of graphite at least as powerfully as aluminium; with 0.1 per cent. titanium in the metal the maximum graphitisation value is already attained.

cast iron by 20 to 30 per cent. With a higher content, owing to too favourable graphitisation—which, contrary to Smalley, is not materially refined by nickel according to the present investigations—a fall in the quality-indicating figures takes place. The improvement of the properties by nickel is mainly attributable to the mixed crystal formation with the iron.

D.—Effect of Chromium (Table IV).

Chromium alone cannot materially improve the mechanical properties of grey iron. The increased hardness from a chromium content of 0.5 per cent. was certainly 20 to 25 per cent., but, on the other hand, the increase in the other mechanical values by the chromium addition in question scarcely exceeded 10 per cent. The chromium in the metal was apparently divided between carbide and ferrite.

Table IV.—*Tests with Chromium.*

Series	Si.	C.C.	Gr.	Cr.	Transverse load in lbs.	Deflection in ins.	Compression, tons per sq. in.	Tensile tons per sq. in.	Shock test.	Brinell hardness
	Per cent.	Per cent.	Per cent.	Per cent.						
I	1.11	0.71	3.06	—	385	0.35	34.2	5.5	1.14	143
	1.06	0.63	2.98	0.15	490	0.34	35.0	5.7	1.26	152
	1.01	0.83	2.97	0.30	385	0.26	35.8	7.3	1.22	154
	1.03	0.97	2.76	0.51	447	0.25	38.2	7.6	1.26	161
II	1.82	0.44	3.26	—	324	0.34	29.5	4.6	1.0	132
	1.80	0.52	3.23	0.14	365	0.34	29.2	5.2	1.06	133
	1.81	0.65	3.05	0.28	376	0.30	32.5	6.7	1.15	141
	1.68	0.80	2.80	0.48	405	0.29	34.2	7.9	1.14	153
III	2.76	0.26	3.45	—	290	0.30	30.8	4.2	0.88	116
	2.71	0.32	3.42	0.14	330	0.29	27.2	4.3	1.22	122
	2.74	0.33	3.41	0.29	315	0.26	28.6	5.8	1.06	138
	2.77	0.57	3.20	0.53	337	0.20	28.2	6.0	1.01	143

Table V.—*Tests with Nickel and Chromium.*

Series.	Si. per cent.	C.C. per cent.	Gr. per cent.	Ni. per cent.	Cr. per cent.	Transverse load in lbs.	Deflection in ins.	Compression. Tons. sq. in.	Tensile. Tons per sq. in.	Shock test.	Brinell hardness.
I	1.11	0.71	3.06	—	—	385	0.35	34.2	5.5	1.14	143
	0.97	0.68	2.91	0.21	0.15	630	0.33	47.3	9.5	1.64	191
	1.10	0.79	2.81	0.19	0.29	560	0.29	51.0	10.6	1.68	205
	0.98	*0.92*	*2.80*	*0.20*	*0.49*	*655*	*0.31*	*58.3*	*11.4*	*1.54*	*229*
	1.04	0.66	2.94	0.39	0.16	454	0.33	36.8	5.8	1.20	175
	0.95	0.80	3.08	0.40	0.32	490	0.30	41.5	6.1	1.26	180
	1.10	0.80	2.96	0.39	0.51	508	0.25	41.5	7.3	1.38	190
	1.08	0.61	2.96	0.74	0.13	455	0.27	38.0	6.8	1.21	169
	1.13	0.74	2.99	0.75	0.29	473	0.28	40.3	7.3	1.39	176
	1.04	0.83	2.78	0.74	0.48	480	0.28	40.7	7.0	1.34	178
II	1.82	0.44	3.26	—	—	324	0.34	29.5	4.5	1.00	132
	1.82	0.55	3.23	0.20	0.14	380	0.32	32.5	5.2	1.10	143
	1.87	0.62	3.04	0.20	0.29	405	0.27	35.5	4.9	1.28	147
	1.74	0.72	2.88	0.21	0.49	460	0.22	40.2	7.1	1.61	158
	1.75	0.47	3.30	0.39	0.14	300	0.26	31.2	4.4	1.08	120
	1.69	0.58	3.26	0.41	0.29	467	0.26	36.4	7.7	1.14	145
	1.75	0.72	2.95	0.39	0.49	550	0.24	48.5	9.2	1.22	174
	1.81	0.37	3.34	0.72	0.15	510	0.31	46.4	8.4	1.15	146
	1.70	*0.47*	*3.28*	*0.70*	*0.32*	*595*	*0.30*	*47.3*	*9.8*	*1.27*	*190*
	1.73	*0.65*	*3.10*	*0.74*	*0.48*	*605*	*0.30*	*49.0*	*10.2*	*1.32*	*186*
III	2.76	0.26	3.45	—	—	290	0.30	28.6	4.2	0.88	116
	2.72	0.25	3.47	0.21	0.14	327	0.23	27.0	5.3	1.08	141
	2.80	0.36	3.30	0.20	0.29	405	0.22	32.3	5.6	1.13	144
	2.75	0.56	3.19	0.19	0.49	427	0.24	33.7	6.8	1.29	152
	2.71	0.23	3.48	0.39	1.13	335	0.24	31.4	4.9	1.04	135
	2.80	0.37	3.37	0.38	0.31	435	0.25	35.0	7.0	1.21	139
	2.79	0.51	3.17	0.40	0.50	458	0.21	43.2	7.3	1.16	161
	2.77	0.22	3.48	0.75	0.14	330	0.23	28.0	4.7	0.97	112
	2.77	0.31	3.44	0.74	0.32	350	0.25	28.2	6.3	1.01	126
	2.79	0.48	3.26	0.75	0.48	528	0.24	40.0	7.6	1.17	131

(2) In Series I and II titanium therefore operates in the same manner as aluminium. In Series III there results, in contrast with aluminium, a material improvement in the mechanical properties, as in this case the compressive strength and transverse strength, and even the hardness, are greatly increased, without the specific shock energy or the deflection being noticeably impaired.

(3) A titanium addition effects, together with increased graphitisation, an extraordinary refinement of the graphitic constituent, which must primarily be regarded as the cause of the enhanced quality.

(4) In grey pig-iron titanium is always present in the form of its non-metallic combinations (nitride, carbide, oxide).

C.—Effect of Nickel (Table III).

A moderate nickel content of 0.5 to 1 per cent. improves the mechanical properties of the grey

E.—Effect of Simultaneous Nickel and Chromium Content (Table V).

The best of the improvements in all the three main series of experiments is with a chromium content of 0.5 per cent. The most favourable nickel content in conjunction with it is in Series I =0.20 per cent., while in Series II and III it is between 0.4 and 0.8 per cent. nickel. These relative proportions serve materially to increase the tensile and transverse strengths, as well as the hardness and compressive strength, without diminishing the specific shock energy and deflection.

The greatest quality increase was in Series I, about an average of 75 per cent., in Series II up to 80 per cent., and in Series III up to 60 per cent.

In the presence of chromium nickel has nothing like such a powerful effect on the formation of graphite as when it is present alone as the special element (*cf.* in the numerical values of the three

series the tests with 0.5 per cent. Cr with reference to the corresponding changes in the graphite content by means of increasing nickel additions).

F.—Effect of Vanadium (Table VI).

In contrast with Smalley, who contests the hardening effect of vanadium, the tests show that this element greatly promotes the formation of carbide. It is remarkable that the effect of the vanadium appears only with additions over 0.5 per cent., but then very suddenly, and the effect is much more marked in the lower silicon Series I and II than in Series III with 2.75 per cent. Si. The hardening effect of the vanadium is expressed in a rapid increase of hardness and compressive strength. Similarly, the transverse strength here attains a very high value (*cf.* the values indicated in italics in Table V). Naturally the types of iron iron with such a high combined carbon content as most of the samples in Series I and II can no longer be used as commercial cast iron; but the fact that, notwithstanding such an unusual hardness increase, it was possible to obtain a transverse strength of 52 kg. mm.[2] (33 tons per sq. in.) under test (with skin on), proves the favourable influence of vanadium on tenacity, which finds expression in Table V in a material increase of the specific shock energy. This observation coincides with the results of Moldenke[3] and others, who found, together with a hardening effect, a material increase of density and durability as a result of vanadium. The tests[4] therefore show the use of vanadium to be successful where it is a question of getting metal with a high shock resistance, high strength and great resistance to wear.

G.—Effect of Tungsten (Table VII).

While according to Smalley only a tungsten addition of about 1 per cent. noticeably influences the properties of pig-iron, the strength being somewhat increased and the hardness diminished, the results of the present experiments show that even 0.5 per cent. W is sufficient to influence materially the mechanical properties of the metal, and that in a favourable sense. Care must, however, be taken that the added tungsten is really dissolved in the iron, for tungsten alloys have a high melting point. Thus, in the present case, the use of a ferro-tungsten of about 82 per cent. led to complete failure. Only after this alloy had been brought by melting with pure soft iron to a tungsten content of about 16 per cent. was the tungsten absorbed by the molten iron.

Tungsten ought to prove a very promising alloy element, as it greatly improves all the mechanical properties of the casting. For, in addition to the transverse, tensile and comparative strengths, the specific shock energy is also increased not inconsiderably, while the deflection remains constant or rather inclined to increase. At the same time tungsten shows only a very mild effect on the carbon structure of cast iron, as it promotes graphitisation feebly.

This notable effect of tungsten, which is most promising in connection with the efforts being made towards improvement, is mainly attributable to the effective formation of mixed crystals by tungsten along with iron, which leads to the appearance of a new structural constituent, tungsten-ferrite, as shown in Fig. 3.

It does not appear impossible that a further increase of the tungsten content would be accompanied by a further improvement in the quality figures.

(To be continued.)

Table VI.—*Tests with Vanadium.*

Series.	Si. Per cent.	V. Per cent.	C.C. Per cent.	Gr. Per cent.	Transverse load in lbs.	Deflection. in ins.	Compression Tons per sq. in.	Shock test.	Brinell hardness.
I	1.14	—	1.51	2.44	578	0.26	51.5	0.40	170
	0.99	0.25	1.58	2.43	604	0.26	66.0	0.42	201
	0.95	0.45	1.45	1.45	682	0.19	71.8	0.42	258
	0.95	0.65	2.50	1.35	*718*	0.18	77.4	0.57	*305*
	0.95	1.05	3.84	0.06	*875*	0.16	98.2	0.59	*436*
II	1.50	—	1.22	2.76	542	0.26	50.5	0.33	170
	1.55	0.20	1.25	2.75	560	0.26	55.0	0.33	190
	1.66	0.45	1.28	2.72	612	0.27	71.0	0.38	195
	1.65	0.75	1.67	2.28	*804*	0.28	77.4	0.41	*242*
	1.70	0.95	1.72	2.23	*910*	0.26	85.0	0.59	*277*
III	2.71	—	0.95	2.95	472	0.30	49.5	0.28	160
	2.85	0.43	0.95	2.90	482	0.29	51.5	0.34	175
	2,82	0.70	1.16	2.69	517	0.26	68.5	0.41	220
	2.85	0.95	1.28	2.52	542	0.24	73.0	0.42	242

Table VII.—*Tests with Tungsten and Vanadium.*

Series.	Si. per cent.	W. per cent.	V. per cent.	C.C. per cent.	Gr. per cent.	Transverse load in lbs.	Deflection in ins.	Compression. Tons sq. in.	Tensile. Tons per sq. in.	Shock test.	Brinell hardness.
I	1.12	—	—	0.87	2.83	410	0.26	37.0	6.1	0.69	150
	1.02	0.27	—	0.81	2.82	592	0.28	44.6	5.2	0.40	155
	1.06	0.42	—	0.72	2.68	640	0.28	61.5	11.6	0.68	201
	1.10	0.21	0.20	0.78	2.73	528	0.24	58.8	7.2	0.59	203
	1.12	0.45	0.20	0.74	2.65	658	0.27	63.2	11.6	1.06	212
II	1.86	—	—	0.65	3.10	515	0.33	43.3	8.2	0.68	161
	1.80	0.25	—	0.55	3.02	542	0.33	46.7	9.2	0.64	163
	1.89	*0.51*	—	*0.51*	*3.23*	*757*	*0.34*	*61.2*	*12.4*	*1.24*	*194*
	1.85	0.29	0.18	0.60	3.01	580	0.35	47.5	10.2	0.69	178
	1.83	*0.49*	*0.21*	*0.58*	*2.83*	*788*	*0.35*	63.0	*13.3*	*1.18*	*199*
III	2.80	—	—	0.44	3.32	410	0.29	40.0	6.7	0.59	173
	2.93	0.23	—	0.38	3.27	610	0.32	42.7	7.6	0.59	159
	2.92	0.47	—	0.31	3.14	610	0.30	48.0	10.1	0.78	180
	2.95	0.26	0.22	0.39	3 25	445	0.30	39.7	7.2	0.85	171
	2.86	0.45	0.26	0.38	3.37	447	0.31	47.5	8.6	0.82	182

[3] "J. Iron and Steel Inst.," 1911, also Kent Smith: contrary view of Smalley; "F.T.J.," 26 (1922), p. 277.

[4] In the tests on the effect of vanadium the casting of the test rods was inadvertently carried out at 1,200 to 1,250 deg., so that the formation of carbide was possibly favoured additionally by the too low casting temperature. But this scarcely altered the characteristic properties of the vanadium addition, but rather caused a parallel displacement of the ascertained values to somewhat higher combined carbon contents with a corresponding displacement in the mechanical values. In each case the figures are naturally comparable, but comparison with the figure series of the other elements taken absolutely is possible only with qualifications.

James Neill & Company (Sheffield), Limited, the Artic Fuse and Electrical Manufacturing Company, Limited, the Non-Ferrous Casting Company, and Alfred Ellison (Black Lake Ironworks, West Bromwich) have been elected members of the Federation of British Industries.

The staff employed by Pease & Partners, Limited, at their Skinningrove iron and steel works have received three months' notice to terminate their engagements with the firm, and the workmen are engaged from day-to-day, the prospect being that the plant may be closed down at any time. Pease & Partners, Limited, are working the Skinningrove plant on a three years' lease, in which they have an option of purchase, but that period has not yet expired.

Discussion on Mr. G. Edginton's Paper on "Oil-Sand Cores."*

Mr. Fist said this sand could be used by the moulder when making wheels on the machine and ramming one cog at a time. In his own practice he used a sand 95 per cent. of which was black floor sand and the other 5 per cent. silica sand, and it cost practically nothing. The oil was mixed with it in the proportion of 144 of sand to 1 of oil. The entire core was formed of oil sand. They also used the sand for all pulleys, cylinders from patterns, and any intricate pattern, as it leaves clean, sharp edges. He would like to know whether Mr. Edginton had experience of a similar class of work.

Mr. Edginton replied that he had, and added that his experience of the use of oil-sand cores for steel castings extended over several years, the results being far better than those previously obtained. The cores were made entirely from sea sand. Tooth gear wheels were made in this sand and very good results obtained.

Mr. Holland asked whether Mr. Edginton had experience of an oil-sand core being changed into some other form through the action of the metal. He produced a specimen, which was examined by the audience.

Mr. Edginton said from what he saw he should say that he had known similar things to happen, and, in his opinion, the mould had been very hot and contained moisture, and when the core was put in and the mould closed, it had remained several hours before being poured. Then the core had probably been attacked by the steam and softened. If, for such a core, Mr. Holland used a little more oil in the mixture, and the mould was well baked, this trouble would be overcome.

Mr. S. Smith said he gathered that the core would absorb moisture. He had understood that the oil sands would not absorb moisture.

Mr. Edginton: They will absorb moisture when put into a hot steam mould.

Testing for Complete Dryness.

Mr. Smith said he should have been inclined to think the explanation of the specimen shown was that too much oil had been left in the core. The oil itself had to be let down. To his mind, one of the great secrets of success in oil-sand cores was the drying. Therefore, he wished to know from Mr. Edginton whether there was any definite method by which one could ascertain whether a core was underbaked, overbaked or adequately baked. If such a method was known, then he thought the oil-sand method was perfect. Without any doubt, it had come to stay. The drying of an oil-sand core was somewhat different from the drying of the ordinary core: in the latter case one had only to get moisture out, in the other one had to get out something more than moisture. If he did not, the core would break down.

Mr. Edginton said by experience a man acquired the ability to judge whether a core was sufficiently dry or not. Colour, he thought, was the only guide. When the core was sufficiently dry the colour was deep brown or chocolate; when insufficiently baked, it was yellow, and would be little changed from the original colour. The moisture content in the core was changed according to the class of work. The quantity of oil for general work was 40 of sand to 1 of oil, and for more delicate cores 25 to 1 was used. What happened in the oil-sand core was like what occurred in the green sand. A film of gas was formed which protected the core.

Small Cores in Large Castings.

Mr. Smith said he was reminded of a little experience he had when oil-sand cores had not been long in vogue. A hydraulic casting, about 10 ft. long, was cast vertically, the bottom flange having a very heavy section. At that time the sausage machine was in use. This core was about 2 in. square. By some means one moulder got hold of a core which was made with ordinary bonding sand, and the other core they had was one which came from the sausage machine. When the casting came on the dressing floor no core could be found where the oil-sand core had been; there was just an indication that something had been there, but the core itself was entirely gone, and the metal to all appearance was solid.

Mr. Edginton said he did not think it good practice to put small cores of this description at the bottom of a casting 10 ft. long, no matter what sand was used.

Small Proportions of Core Oil Advocated.

Mr. Fist said his experience was that the less oil used the better the job and there was a great saving in the cost of the oil. Additionally, the core was safer. If an oil-sand core could be made with a proportion of 100 to 1, why use 30 to 1?

Mr. Orme observed that with sea sand or open sand a proportion of 100 to 1 or 144 to 1 was not a practical proposition for foundrymen.

Mr. Edginton said it was fairly obvious why Mr. Fist could obtain results when using only 1 of oil to 144 of sand. He was using a sand with a strong natural bond already there, and what he did was to improve this bond by using a small quantity of oil. It was a very different matter when using only sea sand, which contained no bond until the oil was added.

Mr. A. Sutcliffe suggested that if after a core had been dried and it was sprayed with oil again and redried it would stand pressure better. Suppose in a small shop the stove had to dry both the ordinary bonding core and the oil-sand core, how would Mr. Edginton advise them to proceed?

Mr. Edginton said it was obvious that the two cores could not be dried together, because the oil-sand core would take much less drying. If there was only one stove, the oil-sand core should be kept as low down as possible, and the ordinary bonding core be put high up. The heat would vary according to the position.

Mr. T. Faulkner said he was one of the members who enjoyed the interesting and instructive experience of a visit to the Broadoaks Works at Chesterfield, with which Mr. Edginton was associated. The visit was a revelation of what was possible with oil-sand cores. At his own foundry he had tried using oil in the proportion of 40 parts of sand to 1 of oil, which Mr. Edginton suggested for general work, and they found it rather insufficient. He thought the proportion of the oil should be a little larger. Had Mr. Edginton ever experienced any difficulty in such a core about a foot in size covered with metal and with an outlet of 2 in. as a means of venting?

Venting Oil-sand Cores.

Mr. Edginton stated there should be no difficulty in such a job. He thought there appeared to be some misapprehension as to trouble arising through the use of too much oil leading to the evolution of gas. He did not think it mattered how much oil was put in; the gas would pass off and get away without any trouble, provided there was an outlet for it.

Mr. H. Jowett said his own practice was to grind the sand in an ordinary mill for three to five minutes, but he gathered that Mr. Edginton did not approve of that; he thought the sand might be crushed too much, or even did not believe in crushing it at all. Had he any experience in casting jobs up to, say, 10 tons with two cores, say, 2 ft. cube, in a green sand mould? How would he overcome the danger of moisture being introduced from the mould into the cores, as such cores were often placed in the mould, two or three days before being cast?

Mr. Edginton replied that there was no danger of getting moisture from the mould into the core if the core was put in dry but not hot. He did not like the pan mill because it crushed the grains of sand; the sand was much better if the grains were whole. The paddle mill was the better one, it cut the sand, mixed it better, and did not destroy the venting properties.

* This Paper appeared in our last issue.

XUM

40 to 1 Sometimes Insufficient.

Mr. A. L. Key insisted that with a 40 to 1 mixing they could not get sand that would hold up with some particular cores. For some time he proceeded upon a theory based upon the experience of other people that it was not necessary to use vents oil-sand cores. He had proved conclusively there were limits to that; some oil-sand cores could not be made without venting. In casting some cylinder heads for 9-in. petrol cylinders they were troubled with sponginess, so he cast it open sand in the stud bosses. Both sand and cast-iron cores were tried without success. There were innumerable vents round the core, and as a result it cast beautifully quiet, but a very short period after casting, after the metal had been lying quiet, it began to boil up. This was on account of there being large blocks of metal for the studs to hold the cylinder head on, and in between those blocks was a large piece of core connected to the jacket core, with a very thin section. The large blocks of sand were so porous, and the connection with the thinner part of the jacket was so fine that there was not sufficient accommodation in that thin part to take the amount of air that accumulated in the thick part. Venting arrangements were made with complete success, and since then if there was any doubt about a job they did not hesitate to put in a vent. As to oil-sand cores holding up against heavy sections, they cast wheels which were run on the boss. The casting weighed 8 tons. Formerly they used loam cores, and it was not an uncommon thing to have the casting scabbed. When they used oil sand the cores came out as clean as any part of the outside of the casting.

There was a limit as to the saving effected by using oil sand. It had been found that some large cores were made more cheaply in ordinary core sand, because there were so many brackets and ribs and flanges, and the core was so irregular that it was difficult to get the core strong enough by packing sand on to it. But taking it generally he agreed that there was a considerable saving, if the workmen co-operated.

Wax Vents Unsuitable.

Mr. J. Masters said in his opinion to use wax wire was an unnecessary expense, and likely to lead to trouble. When put into the oil sand the region round the wax wire was much more difficult to fix, and eventually when it hardened they obtained a composition which was not beneficial to the core, and there were isolated patches of material which gave off more gas than was advisable. After initial trials their use was discarded. Everybody was not in a position to use a sand mixer. Mr. Edginton recommended, with large cores, rubbing the blacking on with the hand. He (Mr. Masters) suggested, however, it was much better to put it on with a brush. The core should be given a coat of blacking, whilst it was on the warm side, but not hot. It did not matter what size the core was. Another point was the difficulty of making large cores stand up. He advised, instead of using irons, as in the ordinary core-making methods, to put in some sand slabs right up to the face of the box, and it would come out the same as ordinary sand. It was much cheaper than irons, and quite as effective. Many people were apt to think oil-sand cores would stand anything, but a certain amount of vibration and distortion did take place, and there must be something sufficiently strong to carry the core without spring.

Specific Gravity of Cores.

The Chairman (Mr. R. A. Miles) said he was rather surprised that so far no one had raised the question of the cost of oils, because the price should have some relation to the specific gravity and the strength of bond. It was quite easy for anybody to make an experiment which would satisfactorily settle this question. When one knew of the price of the material, the weight and also the gallons one received to the hundredweight, in other words the specific gravity, he could adopt a simple method of making, say, a 1 in. × 1 in. core according to the formula supplied by the sellers. He could then make a horizontal test on 6 in. or 4 in. centres on the strength of the bond in the core. Having done this it would be quite a simple matter to reckon up which was the most economical oil to buy.

He was amongst the first in the Lancashire district to make experiments with oil-sand cores, and he recalled the first time he used it, some 17 years ago. It was a job which required a core about 4 ft. 2 in. × 2 ft. 1 in., and only 2½ in. thick. The moulder in charge of the job was afraid to pour the casting, and he, the Chairman, had to do the pouring himself. The result was very satisfactory, and some 80 of these castings were made successfully, and some eight hours dressing time was saved on each casting.

He believed many foundrymen still had misgivings about oil-sand core practice; they were afraid of it. His own opinion was that the gravest mistake which is made in the mixing of oil sand is in the quantity of oil used, and he asserted that the thinner the oil and the less quantity used, that is the largest sand-oil ratio, would give the very best results.

Mr. Jolley observed that they found they obtained the best results by adding a definite quantity of water to the dry sand. Their practice was to add the water in the proportion of 1 part of water to 30 parts of sand.

Physical Properties of Core Oil Outlined.

Mr. Phillips (Metropolitan-Vickers) said there were still considerable difficulties in the manufacture of oil-sand cores. The difficulty was to obtain a core oil that would have sufficient strength to enable the core to be handled in the green state. Its viscosity must be low to permit of its mixing with the sand, and the film value must be high in order that it might bind a large quantity of sand. The oil must oxidise at such a rate that the core baked readily, and in the oxidised condition should enable the core to withstand the wash of molten metal. Further, when properly baked, the core should not be susceptible to atmospheric moisture. He would like to have Mr. Edginton's views on the question of drying oil-sand cores in two distinct operations. (1) Drying at a low temperature to remove the moisture, and (2) baking at a higher temperature to oxidise the oil and give strength and hardness to the cores.

What in Mr. Edginton's opinion was the lowest drying temperature at which the conversion of the oil takes place, and what is the highest permissible drying temperature? Also, as it was recognised that the permeability of an oil-sand core was one of its most important properties, was a core less permeable as the temperature rises?

It has been proved that there existed a relationship between the permeability and the initial moisture content of an ordinary sand core, did this relationship exist in an oilsand core? If the initial moisture content had an appreciable effect on the permeability then it was necessary that the sand must be dried and a definite amount of water and oil added.

Mr. Edginton said the best temperature for drying these cores was between 300 and 400 deg. F. In his opinion the permeability was not diminished as the drying temperature rises. Also, he did not think initial moisture had any effect on the permeability if the oil-sand core was properly baked.

A vote of thanks to Mr. Edginton was proposed by Mr. H. Sherburn, who suggested there was a need for a scientific explanation of the best type of oil for the foundryman to use. He did not mean that it should be concerned with the preparations and mixtures, which, under a number of trade names, were sold by various people, but an explanation of the fundamental principle involved and the properties required of a suitable oil which were really required. This information would provide an indication of the general lines on which a foundryman should proceed in making his choice. Foundrymen were now trying to get at the basis of the constitution of cast iron: an attempt should also be made to get at the basic principles in connection with these oils as sand binders.

The vote of thanks was seconded by Mr. Demain, and carried unanimously.

The Cleveland Ironworks, Horseley Fields, Wolverhampton, were put up for auction on April 1 by Mr. D. J. Shedden, of Dudley, and were disposed of for £5,000. The Cleveland Works were owned by George Adams & Sons, Limited, of the Mars Ironworks, who recently went out of business.

SHIPPING, ENGINEERING & MACHINERY EXHIBITION

Incorporating the YACHT, BOAT & MARINE MOTOR EXHIBITION.

OLYMPIA, LONDON, Nov. 23rd to Dec. 5th, 1925

Under the Patronage and with the active support of
THE BRITISH ENGINEERS' ASSOCIATION (Incorporated).

For plans and full particulars of space available apply :—
Exhibition Offices : Avenue Chambers, 4, Vernon Place, London, W.C.1
Telegraphic Address : Segdirb (Westcent) London. Telephone No. : Museum 6663 & 6664.

Telephone : 21, Penistone. Telegrams : "Durranns, Penistone."

ESTABLISHED 1863.

JAS. DURRANS & SONS., LTD.

Phoenix Works, Penistone NEAR SHEFFIELD.

BLACKING
PLUMBAGO
CORE GUM
WHITE DUST
COAL DUST

Manufacturers of

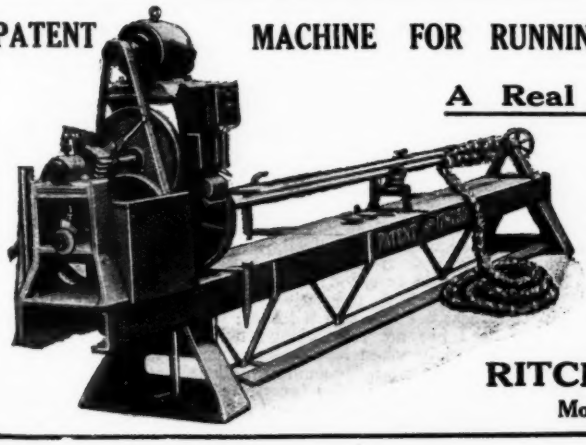
FOUNDRY EQUIPMENTS.

Ladles, Cupolas, Fire Bricks, Ganister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Write for illustrated catalogue on Blacking and Foundry Requisites, also for our latest Price List.

PATENT MACHINE FOR RUNNING LOAM CORES ON BARRELS

A Real Labour Saver.



Cores any length and diameter, OPERATED BY ONE MAN. Driven by motor or countershaft. Machines in use for cores 28 ft. × 30 in. diameter. Patent No. 178750.

Testimonials from Iron and Brass Founders.

RITCHIE HART & CO., LTD.

Mount Pottinger Foundry, BELFAST.

Trade Talk.

The Machine Tool Trades Association have decided to hold their next exhibition in 1928.

Woodfield & Company, crane, etc., makers, have removed from Westminster to Samudas Wharf, Manchester Road, Millwall, E.14

A licence under the Non-Ferrous Metal Industry Act, 1918, has been granted by the Board of Trade to E. C. Trubridge, Limited, Abbey House, Victoria Street, London, S.W.1.

The Rhodesian Railways Administration have increased the order they recently placed with Beyer, Peacock & Company, Limited, Gorton, Manchester, for four Garratt locomotives to 12.

Mr. M. Spitzer, 16, Devonshire Square, London, E.C.2, has been appointed British and Colonial agent for the bright turned steel shafting made by S./A. des Barres Cylindriques de Precision of Wandre, Liege, Belgium.

The Vickers Spearing Boiler Company, Limited, 20, Kingsway, London, W.C.2, have a set of lantern slides illustrating various types of water tube boilers and chain grate stokers, which they are prepared to loan for lecturing purposes.

The Leeds Forge Company, Limited, of Leeds, have received an order from the Crown Agents for the Colonies for one hundred all-steel bogie covered goods wagons for the Uganda Railway. This is the eleventh order for this type of wagon received since the year 1912 by the Leeds Forge Company, Limited, who originally designed it.

Edgar Allen & Company, Limited, Imperial Steel Works, Sheffield, have lately received several contracts for cement making plant. One of these is a complete plant with electric motor equipment for the Dunstable Portland Cement Company, having a capacity of 110,000 tons per annum. It includes two 200 ft. rotary kilns and patent combination grinding mills. A second contract is a complete plant for the Standard Portland Cement Company, Limited, of New South Wales, with a capacity of 100,000 tons per annum, designed to operate the dry process.

An amalgamation is being arranged between the Broken Hill Proprietary steel works at Newcastle and Rylands Bros., Australia, Limited, whose wire and netting works are also at Newcastle. Mr. Field, of Rylands Bros., Limited, Warrington, who is at present in Australia, has stated that Rylands' premises adjoined the Newcastle steel works, and drew steel supplies from that factory. The Broken Hill Company had selling organisations throughout Australia, and also large shipping interests, and therefore the merger was to their mutual advantage. Mr. Field left for England on April 7.

Obituary.

Mr. R. T. Hughes, J.P., brother of Sir Collingwood Hughes, Bart., and principal of the firm of Hughes, Bolckow & Company, Limited, shipbreakers, died on April 5 at Saltburn. The firm has large establishments on the Tyne and at Blyth, and have broken up some of the most famous battleships in the British Navy. They also purchased large dumps of war materials in France.

Mr. J. Torbock, of Crossrigg Hall, near Penrith, who died recently, was closely associated with the iron trade on Teesside. He was 73 years of age and had been in failing health for some time. Mr. Torbock, before settling in Westmorland nearly 30 years ago, lived at Redcar; then he leased Crackenthorpe Hall, Appleby, and after living for some years at Morland Hall he in 1913 purchased the Crossrigg Hall estate. He was a magistrate for Westmorland for exactly 25 years, and held numerous public offices. He was chairman of the Forsett Limestone Company, Limited, and the North African Mining Company, Limited, and a director of the Linthorpe-Dinsdale Smelting Company, Limited, and the Indian Manganese Company, Limited.

Mr. T. J. Reynolds, who for many years has been in charge of the installation of all turbo-generator plant manufactured by the British Thomson-Houston Company, Limited, has died at the age of 49. Mr. Reynolds had been in bad health for some time, and his death will be greatly regretted, not only by the company, but also by very many central station and other engineers throughout the country, amongst whom he was widely known and very highly respected. For the past 22 years, Mr. Reynolds had been closely identified with B.T.H. turbines, and he was recognised as having unique experience and skill in their installation and maintenance. He was trained in the steam and mechanical engineering departments of Combe, Barbour & Combe, Limited, Belfast, and after many years in the merchant service joined the B. T. H. Company's construction staff, being placed in charge of his department in 1913.

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Business in the Cleveland iron market having been practically suspended during the current holiday week, there is very little change to note in the general position of the iron trade, which, for the time being, remains as unsatisfactory as previously reported. Export business is also quiet, and the increasing instability of the franc gives added uncertainty to the outlook. The quotation for No. 3 G.M.B. is unchanged at 77s. 6d. per ton, though probably this could be shaded for substantial business. No. 1 is 82s. 6d., No. 4 foundry 76s. 6d., and No. 4 forge 75s. 6d. per ton.

Hematite is very weak, although producers look for some improvement as the result of the curtailment of output. Sales have recently been made at 82s. 6d., and though in some cases there is a disposition to hold out for 83s., the lower figure must be taken as the general quotation. The No. 1 quality is 6d. per ton more. On the West Coast prices are generally unaltered, Bessemer mixed numbers being 90s. c.i.f. Welsh ports, 94s. 6d. per ton delivered at Glasgow, 100s. per ton delivered at Sheffield, and 102s. 6d. per ton delivered at Birmingham.

Scrap.

Very few actual transactions can be traced this week as far as the scrap metal markets are concerned, and in Lancashire foundrymen have practically ceased buying for the time being. As a rule local dealers are holding out for 85s. for the best cast scrap and 80s. to 82s. 6d. for common lots, but some of the weaker holders have been accepting lower rates. In any case it is expected that prices will be lower after the holidays, and dealers are rather anxious as to the stocks they are holding. In Scotland, machinery cast-iron scrap has been recently sold at 86s. 3d. and 87s. 6d.

Metals.

Copper.—The tendency of standard values downwards has, so far, continued unchecked, while the hand-to-mouth policy of buying which has been a prominent feature for some time is emphasised by the fact that requirements are quickly satisfied and a rally cannot be maintained for more than 24 hours at a stretch. There is certainly but very little confidence expressed in the metal at the moment, and there may be some further downward fluctuation before the position becomes settled. Current quotations:—*Cash*: Wednesday, £60 15s.; Thursday, £61; Tuesday, £60 17s. 6d.; Wednesday, £60 7s. 6d.

Three Months: Wednesday, £61 15s.; Thursday, £62; Tuesday, £61 17s. 6d.; Wednesday, £61 7s. 6d.

Tin.—Regarded from the statistical point of view, it is difficult to understand the recent weakening of values of the metal. Occasionally there has been some good buying, but, on the other hand, there has been some aggressive selling, the persistency of which has had a telling effect, while the situation has been further complicated by the weakness in the red metal. As a matter of fact, present prices are not warranted by the actual situation. The consumption of tin continues very good, but at the same time the trade outlook in metals generally has rather deteriorated. Current quotations:—*Cash*: Wednesday, £233 5s.; Thursday, £232; Tuesday, £229 5s.; Wednesday, £229 15s.

Three Months: Wednesday, £236 10s.; Thursday, £234 15s.; Tuesday, £232 5s.; Wednesday, £233 5s.

Spelter.—Market movements in this metal of late have developed an irregular tendency, with values, however, inclining to slightly improving figures. Liquidation for the time being appears to have ceased, and the metal is now steadier. The present range of values is relatively low, and this should stimulate consumptive buying. Galvanisers are wanting orders very badly, but they are poorly provided with zinc, and any improvement in the sheet trade would have due effect. Current quotations:—*Ordinary*: Wednesday, £35 2s. 6d.; Thursday, £35 5s.; Tuesday, £34 17s. 6d.; Wednesday, £34 15s.

Lead.—Fluctuations in values of soft foreign pig of late have had a distinctly downward tendency, and the opinion is freely expressed that the days of inflated prices are over, for the time being at all events. Generally speaking, the outlook favours a still lower level; stocks are now accumulating; the seasonal demand for lead has not come along; holders are very nervous, especially where lead is being financed with dear money, and bears are becoming jubilant. Current quotations:—*Soft foreign (prompt)*: Wednesday, £32 15s.; Thursday, £33; Tuesday, £32 17s. 6d.; Wednesday, £32 7s. 6d.